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NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS.

MECHANICS' INSTITUTE SAN FRANCISCO

TRANSACTIONS.

VOL. VI.

1857-8.

NEWCASTLE-ON-TYNE: ANDREW REID, 40 & 65, PILGRIM STREET.

1858.

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The Institution is not, as a body, responsible for the facts and opinions advanced in the following Papers read, and in the Abstracts of the Conversations which occurred at the Meetings during the Session.

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Report.

In conveying to the members of the Institute, generally, a review of the proceedings of the year just closed, which it now becomes their duty to do, the Council have to Report, that the progress made by the Institute has been satisfactory.

The papers read during the year just passed are fewer than in some of the preceding years, but they are equally important, and some of them of a peculiar practical nature; and the discussions at some of the meetings have been highly interesting and instructive.

In November last a paper was read, by Mr. Joseph Bewick, on the Ironstone Deposits of Rosedale, a paper, which, combined with that of Mr. John Marley, on the Cleveland Ironstone generally, has aided in elucidating the great ironstone formation of Cleveland, which has so powerfully attracted the attention both of the scientific and commercial world. And the special discussion which took place at the July meeting, especially on the Rosedale ironstone, has tended to throw additional light upon that peculiar and important deposit.

A valuable paper was also read by Mr. Henry J. Plews, of Bedale, on the Coal-field of New South Wales, accompanied by elaborate maps and figures of the several fossil remains found in that important coal-field. Specimens of several of the fossils of this formation, nearly agreeing with those of the British coal measures, were exhibited by Mr. Plews, and presented to the Society.

The Institute has also this year been favored by Mr. T. Y. Hall with extensive statistical calculations and statements of the Production and Consumption of Coal in France, with map.

At the May meeting a short but instructive paper was read by M. Laurent, and a model exhibited, illustrative of a plan of machinery for Ventilating Mines, invented by M. Lemielle, and now in operation in some of the coal mines in France. And, at the June meeting, Mr. J. J. Atkinson, Inspector of Coal Mines, favored the meeting with some elaborative calculations and investigations on the efficacy and economy of such machine, as compared with the furnace and some other modes of ventilating coal mines.

The discussion on the Lundhill Accident, and on the Ventilation of Coal Mines generally, has occupied the meetings of the Institute, a subject peculiarly applicable to the Society. And, at the May meeting, and subsequently, papers were read by Mr. Atkinson, illustrative of the Distribution of Air in Coal Mines, and, more especially, on the subject of Splitting Air, and the advantages derived therefrom, and, likewise, on the laws which govern currents of air passing through, and distributed throughout mines in different states of atmospheric influences.

At the August meeting, a paper on the Ventilation of Mines, as connected with the system in use at Lundhill colliery at the time of the accident, and on the system of working and ventilating the coal mines of that district, illustrated by drawings, was read by Mr. John Wales, who also exhibited diagrams of the different modes of ventilation, and which led to a most important practical discussion of the ventilation of the coal mines above alluded to, and of coal mines generally.

These papers, and such of the discussions as could be embodied in the proceedings of the Institute, will constitute important additions to the earlier volumes of the "Transactions" of the Society.

The Council are glad, also, to report an increase of members, the number added during 1857-8 having been twenty-eight. The Society has, however, to lament the loss of three members by death, viz., Mr. Ralph Dixon, of Durham, Mr. E. Southern, of Kibblesworth, and

Mr. George Heckles, of Shincliffe. The Council have, also, to lament the loss of one of the honorary members of the Society, Mr. Herbert Mackworth, Inspector of Coal Mines, who died on the 13th July, at the premature age of thirty-four. Thus, therefore, the nett increase of ordinary members in 1857–8 is twenty-five.

On the question of finance, the Council, as usual, refer to the Report of the Treasurer and Finance Committee. On this subject it may be stated that the Council have had under their consideration the expence of printing the papers of the Society, and will have to lay before the meeting, a communication which, if adopted, it is expected may reduce the cost of publication of their "Transactions."

On the subject of the Proposed College of Mining and Manufacturing Science, the Council are glad to inform the meeting that they have had communications with the authorities of the Durham University, from which they augur favorable results. Without at present going further into the subject, they may state, that it is their anxious wish; and the meeting may rest assured that all the efforts which they can employ will be devoted to the accomplishment of so desirable an object. And they venture to hope, that they will, shortly, be enabled to lay before the members of the Institute, some practical proposition for their consideration. They, at the same time, beg to recommend that a renewed application be made to the Coal Trade of the district for their assistance in enabling them to overcome the financial difficulties with which the scheme is at present environed.

The Council hardly know whether it falls, strictly speaking, within their province to advert to the interesting series of experiments still in progress, and now proceeding under the supervision of Commissioners appointed by the Board of Admiralty, on the consumption of the smoke of coal, and on the relative evaporative values and powers of different British coals. As, however, the original experiments instituted by the Northumberland Steam Collieries' Association, and the reports of the results of that series from which the present investigation has arisen, were conducted by three scientific gentlemen, all ordinary members of this Institute, the Council feel it not improper briefly to refer to them. That the final results of the elaborate enquiry now making, under the

auspices of the Board of Admiralty, will prove of high interest, not only to the coal-owners of these districts, but to all owners of coal mines, and to all interested in the use of coal for marine and manufacturing purposes, they cannot doubt, and they, accordingly, congratulate the meeting on the position in which this important question is now placed.

Finance Report.

Your Finance Committee have examined the Treasurer's Accounts for the last year, and beg to submit the same for your inspection.

The balance in hand has decreased from £725 1s. 0d., in August, 1857, to £638 19s. 0d., in August, 1858, arising from the purchase of Lindley and Hutton's fossils chiefly, together with the additional expense of publications requiring costly illustrations.

With reference to the Library, the Committee beg to recommend a continuance of outlay on this head, in accordance with the resolutions already passed.

Your Committee are sorry to say they cannot meet the members with the same satisfaction as last year, in consequence of the suspension of the Northumberland and Durham District Bank, where you have £600 deposited; however, it is expected that the money will, ultimately, be recovered, with interest, in time to meet the requirements of the Society.

At the commencement of the Institute tenders were received for printing the papers of the Institution. They now submit for consideration the propriety of receiving tenders again for printing and lithographing the Society's works.

The Committee further take leave to suggest that a catalogue of all books, plans, sections, geological, and other specimens, and models, be made out to accompany the Transactions, and that the additions be recorded in succeeding years in the Annual Volumes.

THE TREASURER IN ACCOUNT WITH NORTH OF

For the Year from August, 1857,

1858.	Dr.				£	s.	d.
July 31.—	To Balance in Hand from Fifth Year				725	1	0
	" Subscriptions collected since Balancing at July 31, 1857, for that and former years				10	10	0
	" Interest on Deposit Receipt in District Bank for 1 year up to August, 1858.—£600 at 4 per cent.				24	0	0
	" Subscriptions from 198 Members				415	16	0
	" Subscriptions from Colliery-owners to this date, viz:—						
	Stella	£2	0	0			
	Lambton	10	10	0			
	Grange	2	2	0			
	Kepier Grange	2	2	0			
	Haswell	8	8	0			
	Black Boy	4	4	0			
	Leasingthorne	2	2	0			
	Westerton	2	2	0			
	Hetton	10	10	0			
	North Hetton	6	6	0			
	South Hetton and Murton	8	8	0			
	East Holywell	2	2	0			
	Holywell Main	2	2	0			
	Barrington	2	2	0			
	Seghill	5	0	0			
	Cowpen	5	0	0			
					75	0	0
	" Sales of Publications, per A. Reid, from July to December, 1857	65	6	11			
	Ditto from December, 1857, to July 31, 1858	20	3	8			
					85	10	7
					£1335	17	7

ENGLAND INSTITUTE OF MINING ENGINEERS.

to and with August, 1858.

1858.	Cr.		£	s.	d.
July 31.—By paid A. Reid, Printing from July to December, 1857	£213 8 6				
" Do. Do. December to July, 1858..	201 13 0				
			415	1	6
" Paid Postage, Secretary	9 15 5				
Do. Treasurer	5 10 6				
Do. A. Reid	25 9 8				
			40	15	7
" Paid Circulars, Account Books, &c.			13	6	6
" Paid Secretary's Salary, One Year, due August, 1858			25	0	0
" Paid Reporter's Salary, One Year, due August, 1858			12	12	0
" Paid for Advertising			9	0	6
" Paid Laws and Glynn for Fossils			150	0	0
" Paid Dr. Richardson: Analysis of Turkish Coal			6	6	0
" Paid Insurance on Property to Norwich Insurance Company.			0	16	6
" Interest on Deposit of £600 in District Bank, not received ..			24	0	0
By Balance in Hands of Treasurer			638	19	0
		£1,335	17	7	

GENERAL ANNUAL STATEMENT, AUGUST, 1857.

1858.	Liabilities.	£	s.	d.

1858.	Assets.	£	s.	d.
July 31.—By	Amount of Cash in Hands of Treasurer	638	19	0
"	Amount of Sheets belonging Vols. 1, 2, 3, 4, & 5	200	0	0
"	Do. Bound Do.	99	0	0
"	Amount of Volume 6	110	0	0
"	Members Subscriptions Uncollected	92	8	0
"	Collier Do. Do.	5	5	0
		£1145	12	0

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154 Plummer, B., 5, Elswick Villas, Newcastle-on-Tyne.
155 Plummer, Jun., R., Quay, Newcastle-on-Tyne.
156 Potter, E., Cramlington, Newcastle-on-Tyne.
157 Potter, W. A., Mount Osborne Collieries, Barnsley, Yorkshire.
158 Powell, T., Newport, Monmouthshire.

159 Ramsay, J., Walbottle Colliery, Newcastle-on-Tyne.

160 Ravenshaw, J. H., Seaham Harbour, Fence Houses.
161 Reed, R. G., Cowpen Colliery, Blyth, Northumberland.
162 Reed, Wm., Cowpen, Bedlington, Morpeth.
163 Reid, P. S., Pelton Colliery, Chester-le-Street, Fence Houses.
164 Richardson, Dr., Portland Place, Newcastle-on-Tyne.
165 Robinson, R., Stanley Colliery, Pease's West, Darlington.
166 Robson, J. G., Old Park Hall, Ferry Hill.
167 Robson, G., Tondû Iron Works, Bridge-end, Glamorganshire.
168 Robson, M. B., Field House, Borough Road, Sunderland.
169 Rogers, E., Abercarne Colliery, Newport, Monmouthshire.
170 Ross, A., Shipcote Colliery, Gateshead.
171 Rosser, Wm., Mineral Surveyor, Llanelly, Carmarthenshire, Wales.
172 Routledge, Jun., Wm., Shincliffe Colliery, Durham.
173 Rutherford, J., South Tyne Colliery, Haltwhistle, Northumberland.

174 Sanderson, Jun., R. B., West Jesmond, Newcastle-on-Tyne.
175 Sawyers, W. G., Whitehaven, Cumberland.
176 Seymour, A., Farnacres Colliery, Gateshead.
177 Shortreed, T., Newbottle Colliery, Fence Houses.
178 Simpson, L., Medomsley Colliery, Durham.
179 Simpson, R., 7, Quay, Newcastle-on-Tyne.
180 Sinclair, E., Morpeth, Northumberland.
181 Smith, C. F. S., Derby, Derbyshire.
182 Smith, F., Bridgewater Canal Office, Manchester, Lancashire.
183 Smith, Jun., J., Monkwearmouth Colliery, Sunderland.
184 Sopwith, T., Allenheads, Haydon Bridge, Northumberland.
185 Southern, G. W., Springwell Colliery Gateshead.
186 Southern, J. M., Whickham Grange, Gateshead.
187 Spark, H. K., Darlington, County of Durham.
188 Spencer, Jun., W., Corporation Road, Middlesbro'-on-Tees.
189 Steavenson, A. L., Woodifield Colliery, Crook, Darlington.
190 Stenson, W., Whitwick Colliery, Ashby-de-la-Zouch, Leicestershire.
191 Stenson, Jun., W., Whitwick Colliery, Ashby-de-la-Zouch, Leicestershire.
192 Stephenson, M.P., Robt., 24, Great George Street, Westminster, London, S.W.
193 Stobart, H. S., Etherley, Darlington.
194 Stobart, Wm., Roker, Monkwearmouth, Sunderland.

195 Storey, T., St. Helen's Auckland, Bishop Auckland.
196 Stott, R., Ferry Hill, County of Durham.

197 Taylor, H., Earsdon, Newcastle-on-Tyne.
198 Taylor, H., Backworth Hall, Newcastle-on-Tyne.
199 Taylor, J., Haswell Colliery, Durham.
200 Taylor, T. J., Earsdon, Newcastle-on-Tyne.
201 Telford, W., Cramlington, Newcastle-on-Tyne.
202 Thomas, H. W., Pinchinthorpe, Northallerton, Yorkshire.
203 Thomas, J. T., Coleford, Gloucestershire.
204 Thomas, W., Bogilt, Holywell, Flintshire.
205 Thompson, John, Marley Hill Colliery, Gateshead.
206 Thompson, T. C., Kirkhouse, Brampton, Cumberland.
207 Thorpe, R. C., Bebside Colliery, Morpeth.
208 Tone, C.E., John F., Market Street, Newcastle-on-Tyne.
209 Trotter, J., Newnham, Gloucestershire.

210 Vaughan, J., Middlesbro'-on-Tees.
211 Vaughan, Thos., Middlesbro'-on-Tees.
212 Vaughan, William, Middlesbro'-on-Tees.

213 Wales, J., Hetton Colliery, Fence Houses.
214 Wales, T. E., Abersychan Iron Works, Pontypool, Monmouthshire.
215 Walker, J. Lakelock, Wakefield, Yorkshire.
216 Walker, Jun., T., High Street, Maryport, Cumberland.
217 Ware, W. H., The Ashes, Stanhope, Weardale.
218 Watson, W., High Bridge, Newcastle-on-Tyne.
219 Webster, R. C., Hoyland Hall, Barnsley, Yorkshire.
220 Willis, Jas., West Auckland Colliery, Bishop Auckland.
221 Wilmer, F., Pensher Colliery, Fence Houses.
222 Wilson, J. B., Haydock Rope Works, Warrington, Lancashire.
223 Wilson, R., Flimby Colliery, Maryport, Cumberland.
224 Wood, C. L., Black Boy Colliery, Bishop Auckland.
225 Wood, Lindsay, Hetton Colliery, Fence Houses.
226 Wood, N., Hetton Hall, Fence Houses, County of Durham.
227 Wood, W. H., 2, Bentinck Terrace, Newcastle-on-Tyne.
228 Woodhouse, J. T., Midland Road, Derby, Derbyshire.

Rules.

1.—That the Members of this Society shall consist of Ordinary Members, Life Members, and Honorary Members.

2.—That the Annual Subscription of each Ordinary Member shall be £2 2s. 0d., payable in advance, and that the same shall be considered as due and payable on the first Saturday of August in each year.

3.—That all persons who shall at one time make a Donation of £20 or upwards, shall be Life Members.

4.—Honorary Members shall be persons who shall have distinguished themselves by their Literary or Scientific attainments, or made important communications to the Society.

5.—That a General Meeting of the Society shall be held on the first Thursday of every Month, at twelve o'clock noon, and the General Meeting in the month of August shall be the Annual Meeting, at which a report of the proceedings, and an abstract of the accounts of the previous year shall be presented by the Council. A Special Meeting of the Society may be called whenever the Council shall think fit, and also on a requisition to the Council signed by ten or more Members.

6.—No alteration shall be made in any of the Laws, Rules, or Regulations of the Society, except at the Annual General Meeting, or at a Special Meeting; and the particulars of every alteration to be then proposed shall be announced at a previous General Meeting, and inserted in its minutes, and shall be exhibited in the Society's meeting-room fourteen days previously to such General Annual or Special Meeting.

7.—Every question which shall come before any Meeting of the Society shall be decided by the votes of the majority of the Ordinary and Life Members then present and voting.

8.—Persons desirous of being admitted into the Society as Ordinary or Life Members, shall be proposed by three Ordinary or Life Members, or both, at a General Meeting. The proposition shall be in writing, and signed by the proposers, and shall state the name and residence of the individual proposed, whose election shall be ballotted for at the next following General Meeting, and during the interval notice of the proposition shall be exhibited in the Society's-room. Every person proposed as an Honorary Member must be recommended by at least five Members

of the Society, and elected by ballot at the General Meeting next succeeding. A majority of votes shall determine every election.

9.—The Officers of the Society shall consist of a President, four Vice-Presidents, and twelve Members who shall constitute a Council for the direction and management of the affairs of the Society; and of a Treasurer and a Secretary; all of whom shall be elected at the Annual Meeting, and shall be re-eligible, with the exception of Three Councillors whose attendances have been fewest. Lists containing the names of all the persons eligible having been sent by the Secretary to the respective Members, at least a month previously to the Annual Meeting;—the election shall take place by written lists, to be delivered by each voter in person to the Chairman, who shall appoint scrutineers of the lists; and the scrutiny shall commence on the conclusion of the other business of the meeting. At meetings of the Council, five shall be a quorum, and the record of the Council's proceedings shall be at all times open to the inspection of the members of the Society.

10.—The Funds of the Society shall be deposited in the hands of the Treasurer, and shall be disbursed by him according to the direction of the Council.

11.—The Council shall have power to decide on the propriety of communicating to the Society any papers which may be received, and they shall be at liberty, when they think it desirable to do so, to direct that any paper read before the Society shall be printed. Intimation shall be given at the close of each General Meeting on the subject of the paper or papers to be read, and of the questions for discussion at the next meeting, and notice thereof shall be affixed in the Society's-room ten days previously. The reading of papers shall not be delayed beyond 3 o'clock, and if the election of members or other business should not be sooner despatched, the President may adjourn such business until after the discussion of the subject for the day.

12.—That the Copyright of all papers communicated to and accepted by the Institute, becomes vested in the Institute; and that such communications shall not be published for sale, or otherwise, without the permission of the Council.

*** It was resolved at the Annual Meeting, 6th August, 1857, that an alteration of Rule 5 should be tried for the twelve months next ensuing; during which there shall be General Meetings only on the first Thursday, respectively, of the months of October, December, February, April, June, and August; an arrangement which was left unaltered by the Annual Meeting in August, 1858.

NORTH OF ENGLAND INSTITUTE
OF
MINING ENGINEERS.

GENERAL MEETING, THURSDAY, OCTOBER 1, 1857, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

The minutes of the Council having been read,

The PRESIDENT, after briefly referring to the minutes read, adverted especially to two topics in them, viz., one with reference to the sale of papers belonging the Institute, and the other to the necessity of altering the time of the General Meetings. He ultimately concluded by moving the following Resolutions, which were carried unanimously :—

First,—"That no separate papers should be sold, or duplicate papers delivered to the members except by special leave of the Council, such leave to be granted only after consideration of each particular case."

Second,—"That in future the General Meetings of the Institute be held at Noon instead of 1 o'clock, and that the Council, preparatory to such Meeting, shall meet at 11 o'clock instead of 12 o'clock, as heretofore."

The meeting next proceeded with the election of gentlemen proposed at the last meeting, as members, when the following were elected :—Mr. James, Llwyncelyn Colliery, Merthyr Tydvil, South Wales; Mr. Francis G. Harker, South Durham Iron-works, Darlington; Mr. Lindsay Wood, Hetton Colliery; Mr. F. H. Pearce, Bowling Iron-works, near Bradford; Mr. Thomas McGee, British Iron-works; Mr. A. Ross, Shipcote Colliery; Mr. W. R. Cole, Bebside Colliery, Northumberland; Mr. John Bell, Normanby Mines, Middlesbro'; Mr. W. Cockburn, Hutton Mines, Guisbro'; Mr. Benjamin Dodd, Blaenavon, Newport, Monmouth.

The PRESIDENT then called attention to the papers which stood for discussion. The first was his own, on "the Underground Conveyance of Coals," and, as it was a subject of much importance, he would be glad to hear any observations from gentlemen present. They would perceive that in his paper he had given some experiments, illustrating the power and capabilities of the several modes of conveyance described by him; but, notwithstanding, he knew there were a great variety of modes adopted at other collieries, and he hoped that gentlemen were prepared to give the meeting some information respecting them. The subject of the paper was worthy of discussion, as nothing was of such great importance as the economical conveyance of coals underground in working coal mines advantageously.

Mr. GREENWELL begged to remark that in the practice in Somersetshire the great object they sought to obtain was, to bring up the pits as great a quantity of large coal as possible. They, however, found, from the peculiar make of the tubs used in the Newcastle district, they could not do so satisfactorily, as the effect of using deep tubs was to increase the quantity of small coal, by the pressure of the large coals on the top. The workmen found it their interest to heap the large coal upon the top of the tub, and the deeper the tub the greater quantity of small coals produced. For instance, if the tub was two feet deep, they would, perhaps, obtain about 30 per cent. small coals; but, if it were only one foot deep, the small would only be about half that quantity.

Mr. T. J. TAYLOR thought such a difference very great, as it appeared double in one case to that of the other. The matter might be thus tested. They sent the coals in chaldron waggons from the pits in the north to the ships; they were then deposited in the hold of the ship, and afterwards sent to the London market, and then lifted out of the ship into the barges by baskets, and yet they found they did not make more than 10 per cent. of small coals.

Mr. BARKUS was of opinion that the size of the shaft determined the length and size of the tub. A tub a foot deep would occupy a large superficial area.

Mr. GREENWELL—If they looked at the quantity of small coals they obtained by a deep tub, they would find it very considerable; and, on the other hand, when the tub was shallow they were sure to obtain a greater proportion of large coal.

Mr. TAYLOR—The men put more small coal in deep than in shallow tubs; but was that the only reason why there was such an additional quantity?

Mr. Greenwell—Yes: probably so.

Mr. Marley thought, in low seams, that the quantity of small coal produced depended much upon the height of the tub, as compared with the height of the seam. If the tub was reduced in height, so as to increase the space between the top of the tub and the roof of the coal, he was of opinion that they would get better weight and a larger class of coal. If, for instance, they reduced the tub from two feet six inches to two feet, they would get more space from the top of the tub to the roof, and so prevent the breakage of coals to get them into the tubs.

Mr. Longridge said, to carry 10 cwt. of coal it required a tub six feet by four feet. He would, however, like to know the size of the tubs used in Mr. Greenwell's district.

Mr. Greenwell—They were four feet eleven inches by two feet four inches, and one foot eight inches in height, and by them they raised 10 cwts. of coal.

Mr. Atkinson, referring to the subject of the paper under consideration, and to the number of horses employed underground, asked what would be the fewest number of horses, which would justify the adoption of a steam-engine underground, under ordinary circumstances?

The President thought that a difficult question to answer, as it depended so much on the situation where the engine was to be placed; but, in favourable situations, he had arrived at the conclusion that where a saving of three or four horses could be effected, it would be desirable to erect a steam-engine.

Mr. Atkinson—Had they to understand by this, that four horses were the lowest number. If that were so, they would find that, with the yearly cost of a horse—say, £60—and with drivers and other expenses, wear and tear of horses, &c., the four horses might be estimated at £300 per annum. Would it not, however, be a difficult thing to get an engine to do the work of four horses for a less sum.

The President replied that, supposing the horses to cost, with keep, wear and tear, drivers, &c., £300 per annum, yet still he thought an engine would be cheaper, and would not cost more than about £200 capital, and would do more work than five horses.

Mr. Barkus—But a good deal would depend upon the duration of the district, with reference to the capital employed.

The President—The engines are now constructed in so little bulk that they could be removed at the end of the week, when the pits are off

work; and, as to the duration of the coal of any district, the capital employed was the only question for consideration, and five horses would cost more than one engine.

Mr. BARKUS—But they could sell the horses after they were done with them, at the same price.

The PRESIDENT—His experience showed him otherwise. He could never sell a horse for the same money he gave for him, after he had been at work in a pit. The engine was comparatively less reduced in value by use.

After some further discussion on the subject,

The PRESIDENT said, as it appeared to be the wish of the meeting that the discussion should be adjourned, he would not trouble the meeting further. He had not, in his paper, given the cost of working, but if they were prepared to discuss that point, or any other matter, it would be more advisable to adjourn the discussion, and the members would then come prepared with estimates. The question was an extremely important one. Before closing the discussion, as he understood that Mr. Reid had an engine at work at the Pelton Colliery, different from any he had described, he would take the liberty of asking Mr. Reid what description of engine it was?

Mr. REID—The mode they adopted at Pelton was similar to that at Marley Hill Colliery, which he thought was taken from that of Pelton, and added that, with reference to the substitution of engine power for horses, a great deal depended on the description of horses. For his part, he was more favourable to ponies than large cart horses.

The PRESIDENT stated that the Marley Hill engine was similar in principle to one erected on the Liverpool and Manchester Railway, by the late Mr. George Stephenson.

Mr. T. J. TAYLOR thought unless they went closely into the subject of cost in underground conveyance, they had better defer the discussion, as there were many circumstances to be taken into consideration.

The PRESIDENT thought so, certainly, but begged to observe that there was one feature in the experiments given in his paper which was worthy of observation, and that was the quantity of steam used compared with the quantity of water evaporated. The experiments, on the ordinary engines drawing coals, gave not more than 30 per cent. of effective service. That was important, as the conclusion resulting from the experiments was, that by raising the steam to a high pressure in the first instance, and working it expansively, there would result a saving of

fuel and a much greater useful effect. Low pressure steam held in suspension a much greater quantity of water, comparatively, than high pressure steam. The experiments showed that not more than 30 per cent. of the water evaporated passed through the cylinders as steam, of the pressure indicated by the elasticity of the steam in the boilers.

Mr. Atkinson stated, that if the experiments showed that only thirty per cent. of the water, heated in the boiler, operated in the engine, as effective steam, and, consequently, that the remaining seventy per cent. of such water was lost to that purpose, while it would certainly indicate that a considerable saving of fuel might be effected by increasing the quantity of effective steam, and thereby reducing the quantity of water so lost, by adopting any precautionary measures to effect that object. Yet it should be borne in mind, that the saving in fuel would fall far short of the same proportion, or seventy per cent., because, if we take a case for example, when the working pressure on the safety valves is is about 30lbs. per square inch, (above the pressure of the atmosphere), then if the water supplied to the boiler be at a temperature of 50°, the heat to be imparted to the water, to convert it into operative steam, would be about $(276° - 50° =) 226° + 972° = 1198°$; while the heat imparted to the water, which is not actually converted into operative steam, would only be about $(276° - 50°) = 226°$; and the fuel required to effect the latter would be less than one-fifth of the fuel required to convert the water into operative steam, taking equal quantities of water in the two cases, there being about 972° absorbed as latent heat by that part of the water which is converted into operative steam, over and above the 226°, which is all that is required to raise the temperature of that part of the water which is lost by priming and by condensation, from its original temperature of 50° to 276°. In the case of seventy per cent. of the water not operating as steam, if we take the fuel consumed as $1198 \times 30 + 226 \times 70 = 51{,}760$, then, if the whole of the water could be rendered operative as steam, the fuel would be reduced to $1198 \times 30 = 35{,}940$, being a saving of

$$\frac{(51{,}760 - 35{,}940) \times 100}{51{,}760} = 30{\cdot}6 \text{ per cent. only, in fuel.}$$

The Chairman—With regard to the water which passed through the cylinders in suspension with low pressure steam, the latent heat required to raise the whole of the water into steam was not, of course, wasted, as the water passed through the cylinders without being raised into steam, but the fuel required to raise that water from 50° to 276° was wasted.

Mr. Thos. J. Taylor—That was another reason showing how necessary it was for some experiments to be tried.

The President stated, he did not think the entire economy of using high pressure steam expansively, in low pressure condensing engines had been fully developed. He was of opinion that, if properly arranged, there would be a great saving by raising the steam to a high pressure first, and allowing it to expand to the required pressure, either in the cylinder or in a reservoir. The old haystack boilers were better adapted for the complete separation of the water from the steam, than the cylindrical boilers, from their great capacity, as a reservoir for steam, and from the steam passing out of the top of the large dome of the boiler, and being almost in a comparative state of rest on the surface of the water, little water is carried off with the steam; whereas, in the ordinary cylindrical boilers without domes, the steam passes out of the boiler, or in contact with the water at a high velocity, and, consequently, a larger quantity of water is carried off.

Mr. Greenwell stated they formerly used the haystack boilers, but they had substituted the cylindrical; in the haystack boilers they never had a case of priming.

Mr. Atkinson would be sorry to see the old haystack boilers introduced again, as they might attain what was required in the cylindrical by placing upon them high domes, or even elevated steam jugs.

The President had done so both in colliery and in marine boilers, he had placed domes at the top of the boiler and found they used a less quantity of coals. The matter, therefore, was worth some attention.

Mr. Barkus knew a case, which was by putting a small cup upon the boiler, by which the steam was made to go in side-ways, and since then they never had any symptom of priming.

The President thought it ought not to be called simply priming, it was, in fact, carrying off the water out of the boiler, if they diminished the velocity they would partially cure the evil. But, independently of that, it was quite clear that low pressure steam held in suspension, mechanically, a much greater proportion of water than high pressure steam, the only economical cure for which was to use high pressure steam expansively in condensing engines.

Mr. Barkus—With respect to the high pressure, he thought that after raising the steam to a certain degree of pressure, a certain quantity of heat passed off into the atmosphere. But, if they raised the steam to a very high pressure, a less comparative quantity of heat passed off.

Mr. Thos. J. Taylor—If Mr. Barkus meant there was more latent

heat retained, that was an argument in favour of high pressure steam.

The subject here dropped, after which the following discussion took place on Mr. Marley's paper "On the Cleveland Ironstone."

The PRESIDENT opened the discussion by observing that the subject was one of great importance, comprising, as it did, an investigation of the mineral resources of a district which, until comparatively very recently, had been almost entirely unexplored; and a district which had effected a complete revolution in the commercial features of the north-eastern part of Yorkshire and southern part of the county of Durham, and which would materially interfere with the other iron producing districts of the kingdom; he would, therefore, be glad to hear any observations on Mr. Marley's paper.

Mr. MARLEY begged to say that in the information already given he detected a clerical error in page 183, at the fourth line from the bottom, where he had used the words "*this main bed*" instead of "*the top bed.*"

Mr. THOS. J. TAYLOR felt great interest regarding Mr. Marley's paper. He for one thought it was not only of local but of national importance, as, if the discovery of the ironstone in Cleveland had not been made, the country would have fallen into the back-ground as regarded the production of iron. The entire produce last year was seven millions of tons, and the demand was at present greater than the supply. It was, therefore, clear the market would have to be supplied from some other quarter than home unless they had made the discovery. He, however, wished to ask a question of Mr. Marley, although not strictly within his province to answer, because it was a commercial question, though one of great importance. The question was this:—Was iron made from the Cleveland stone at a lower cost of production than that from clay ironstone under similar circumstances?

Mr. MARLEY said, certainly the iron made from Cleveland stone was cheaper than that made from clay ironstone; but he did not feel himself at liberty to express an opinion as to whether it was made best and cheapest at Middlesbro', or in what other part of the Cleveland district, as the question was a disputed one, and, at the same time, one in which a great many interests were involved in the answer.

Mr. POTTER—It was undoubtedly a comparative question; and, perhaps, Mr. Marley could say whether it was made cheaper at Middlesbro' than at other places?

Mr. T. J. TAYLOR said that he did not refer to any particular place.

The PRESIDENT to Mr. Taylor—You referred generally to the

comparison of the Cleveland stone, with the clay ironstone. The strongest case for comparison, as regarded cheapness of production, was in the Consett Iron-works. These works were placed on the Lanchester Common where the ordinary clay ironstone abounded, and which was as cheaply worked as at any place, as it was worked within twenty fathoms of the surface, and, he believed, worked for from 8s. to 9s. per ton, which he thought was below the average price for working clay ironstone. Before the discovery of the Cleveland stone these works were entirely supplied with clay ironstone, worked in the vicinity of the works, but at present they did not use any clay ironstone, but brought the Cleveland stone from a distance of about fifty miles. This he considered a strong case.

Mr. Thos. J. Taylor—But not a satisfactory one, because they could not obtain the quantity of clay ironstone they wanted. It was well known that clay ironstone made better iron than the Cleveland ironstone.

The President—The want of clay ironstone was not the difficulty, as they could work what quantity they required, and there was a supply for a great number of years. It was entirely a question of cost. They mixed some hematite ore with the Cleveland stone, and made, he believed, a very good quality of iron. It appeared, however, that a mixture of clay ironstone with the ironstone of Cleveland greatly improved the quality of the iron.

Mr. Barkus understood that the clay ironstone yielded from twenty to thirty per cent., while that described by Mr. Marley yielded about thirty-five per cent.

Mr. Marley—Undoubtedly he stated the yield of the Cleveland stone to be 35 per cent., but, still, in general the yield was not more than 33⅓ per cent. With reference to what the President said respecting Consett clay ironstone being worked at 8s. per ton, he had not seen any account of it, but, from his experience of working ironstone, when it was debited with everything, it would not cost less than 10s. per ton. Taking, therefore, the railway carriage into account, the Cleveland stone would be the cheapest; the ordinary clay ironstone did not yield more than from 28 to 33 per cent., except in particular instances.

The President—When he said 8s. per ton, he was aware that it was below the average, and that generally the clay ironstone would cost more, but its quality was, no doubt, generally superior.

Mr. Longridge thought it was stated that the clay ironstone was three per cent. better than the Cleveland stone in the yield?

Mr. Thos. J. Taylor stated that some nodules realized from 38 to 40 per cent.

The President here presented for examination a specimen of ironstone, formed (as he said), of globules of iron cemented by silicious matter, and which was highly magnetic, from the Rosedale beds; after which he proceeded to observe, that according to Mr. Marley's paper the general features of the district were a top and a main bed, with a great mass of shale intervening, from 150 to 250 feet in thickness, and this might be deemed the general geological characteristic of the entire district.

Mr. Marley begged to say that the so-called top seam was in some places divided, and about four feet in thickness, and consisted of thin bands and nodules, interstratified with shale.

Mr. Forster—The main bed occurred throughout the whole district, but was most extensively worked at Eston.

The President—But, looking at the general features of the district, there were two beds, with a very thick mass of shale intervening, and, it appeared to him, that the upper bed increased in thickness southward, and was also richer. It did not occur at Eston, but at Staiths it did, and the quality there was superior to the main bed at Eston. With regard to the quality of the main bed he believed the reverse was the fact, viz., that the quality was superior in the north, and that it was divided, and inferior towards the south. Mr. Marley also stated there was a third regular bed at Ingleby, of less thickness than the top and main bands, and not so valuable, owing to its being divided by bands of shale. He had had occasion to go through the Rosedale district recently, and had examined the ironstone there, especially the quarry alluded to in Mr. Marley's paper, in which an analysis is given of what is called the top stone. At this place there is exhibited a sort of deposit of very rich magnetic ironstone in connection with the top bed of the Cleveland district. The top bed occurs all around the valley of Rosedale, cropping out to the surface all around the crest of the valley. But in some parts of the valley, in addition to this bed, and distinct from it, was this other bed or mass of ironstone, which, as yet, had not been fully developed, and it was not yet clearly ascertained whether it was a regular bed or a casual deposit. It was, certainly, neither the top nor main bands, nor yet the third bed, alluded to by Mr. Marley. Its general character was nodular, and it was destitute of shells, and was highly magnetic, which was not the case with either the main or the top bands. An inspection of the quarry alluded

to by Mr. Marley showed that it differed from the other stones in this respect, that while the top and main seams were connected or interspersed with layers of shale, this bed was devoid of shale, and was one uniform mass of ironstone, nodular, and forty to fifty feet in thickness, and magnetic. The position was distinct from that of the top bed, which, as previously stated, occurred all around the crest of the valley. The drift was set in to ascertain whether it was a continuous bed or a casual deposit, and, so far as the drift had proceeded, and which was about 100 yards, the character was the same as in the quarry, and about the same thickness. This drift had passed through a slip dyke, which, he thought, ran parallel with the valley; and, he believed, that the occurrence of the outcrop of this deposit in the quarry was the result of that slip throwing the stone out to the surface. There, also, was another locality, about two miles up the valley, where a deposit of a similar description of stone was found, but it had not yet been fully explored, though an exploring drift was at present being made. At the quarry a drift had been driven about 100 yards, and it was intended to drive it 100 yards further, with the view of ascertaining whether it was continuous or not, and, if it extended to a distance, or was a casual deposit. It was, certainly, an extraordinary mass of ironstone, was much more rich in yield than either of the three beds in the district, and, as I have before stated, was devoid of shells, and was highly magnetic.

Mr. Marley replied, that the top seam was at Eston, but divided. As to quality, he apprehended the President's remarks applied to per centages, or quantity, more than to quality. And, as regards the Rosedale Abbey ironstone, was it a bed or a vein?

The President—It was certainly not a vein, and occurring in localities two miles apart, and having been found to exist 100 yards in extent, and above 50 feet in thickness, in one locality it appertained more towards a bed than a vein. It was possible that it might partake of the nature of the hematic ironstone formation of Cumberland, which, though not always continuous, was of great extent. It was certainly entirely distinct from the other beds of the district.

Mr. Marley wished to ask the President if he considered that what he (Mr. M.) termed magnetic ironstone, was distinct from the top seam, which he (Mr. M.) held the ironstone, two miles up the valley, to be? And, if so, whether it was below or above the main bed?

The President—It was above the main bed.

Mr. Marley—The next question he asked was whether the stone in Rosedale was ascertained to be a bed or a casual deposit?

The PRESIDENT—That had not yet been ascertained. Professor Phillips and himself had examined it at the same time, and had given directions for certain explorings to be made to ascertain this fact, but they had not yet been sufficiently advanced to speak with certainty on this subject. All that had yet been ascertained was that it occurred in two localities two miles apart, and that at one of those it was 150 yards in width, and from forty to fifty feet in thickness.

Mr. MARLEY thought they would perceive a difference between the per centage of the stone in the drift, and that of the quarry, as, also, of that two miles up the valley.

The PRESIDENT replied that there was no doubt a variety in the analyses which depended much upon what specimens they employed in the analyses, but so far as Professor Phillips's inquiries and his own went, they did not discover any difference. The great test of the superior quality of the ironstone was in the produce of iron in the smelting, and as some thousand tons of it had been smelted, there was no doubt of its superior yield over that of other beds.

Mr. MARLEY was inclined to believe that this mass of stone was a casual deposit, and that it still remained to be proved that it was a bed.

The PRESIDENT would take the liberty of alluding to another point in Mr. Marley's paper, further north. Mr. Marley had given a section of the coal measures at Castle Eden, and had extended them towards the Tees, shewing the coal measures *in situ* underneath the red sandstone in that locality, and as it appeared from the sections not more than 100 fathoms underneath. Now, he thought the coal measures lay at a greater angle than shown on the section, and cropped out into the magnesian limestone before reaching the Tees, and if so, coal would not be found on the South of the Tees.

Mr. MARLEY—It was a continuation of the coal strata from Castle Eden, and the accuracy depended upon the inclination of the beds southward towards the Tees, which has never yet been proved.

The PRESIDENT thought the inclination of the coal measures more rapid southward than shown on the section, especially towards the crop, and that the southern edge of the great coal basin of Durham cropped out into the magnesian limestone, and did not pass underneath it. If he had drawn the section he would have shown the coal measures passing into the magnesian limestone and red sandstone between Castle Eden and the Tees.

Mr. MARLEY—If he looked at the diagram referred to, on page 219, he would observe that the Oughton boring, which is 87½ fathoms deep,

is shown as not through the sandstone. He had it upon good authority, that the five-four seam, supposing it went up to the lower red sandstone, was not distinct, whether it did so as an outcrop or a dip dyke.

The PRESIDENT—His idea was this, that there was a "swally," or depression in the coal measures running from the Auckland district through Rushyford eastward. On the south side of that "swally" the coal measures rose rapidly to the surface, as at Shildon and Cockfield Fell. Further east the magnesian limestone deposit occurred, and there the coal measures cropped out into the magnesian limestone, as at Trimdon and Wingate Grange district, and that they did not pass underneath the Tees near the sea. Further west, into Yorkshire, the magnesian limestone rested on the millstone grit, showing the coal measures wanting.

Mr. REID—This might be the case except at Boroughbridge.

The PRESIDENT—The magnesian limestone was found, at Knaresborough, resting on the millstone grit; the shale beds of the latter forming the strata in which the mineral waters of Harrogate were found. No coal measures, however, existed in that locality; whereas, further north in Durham, the coal measures cropped out to the surface on the western margin of the coal-field, and into the magnesian limestone eastwards.

Mr. MARLEY—The first was between Cockfield and Shildon.

Mr. BARKUS had examined one place at Wensleydale, in the mountain limestone, and following these beds down to Bedale, there it was found that the magnesian limestone rested on the grit rocks.

The PRESIDENT—Magnesian limestone, being a subsequent and independent deposit, rested upon almost all the older rocks in some localities or other; and he believed that if the borings were continued sufficiently deep on the south of the Tees at Redcar, they would meet with the millstone grit, and not that part of the coal measures which contained the known beds of workable coal. He could not, therefore, adopt Mr. Marley's views of the subject, as shewn by his sections.

Mr. MARLEY pointed out that his paper merely went to show that the matter "is, until proved, ideal, and only a *possible* fact;" and that, as yet, no geological fact has been *proved,* which rendered the continuation of the coal measures *impossible.*

At this stage of the proceedings Mr. T. Y. Hall's paper "Notes on the Coal Production of France" was read, and the discussion was adjourned until the meeting in December.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, DECEMBER 3, 1857, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

WILLIAM BARKUS, ESQ., IN THE CHAIR.

The CHAIRMAN, on taking his seat, briefly apologized for the absence of the President of the Institute, who was prevented from attending from indisposition. No one regretted his absence more than himself, as his presence and general usefulness always had great influence upon all their meetings. He, therefore, hoped they would soon see their excellent President speedily restored to health, and once more amongst them.

The SECRETARY having read the minutes of the Council, the following gentlemen were elected members of the Institute:—Mr. George Dixon, Whitehaven; Mr. Wm. J. Ledwood, South Bank Iron-works, Eston Junction, Middlesbro'; Mr. John Thompson, sen., Marley Hill Colliery; Mr. John Dean, Colliery Owner, Tranent, N.B.; Mr. Wm. Cochrane Carr, Blaydon; Mr. Wm. Thomas Mulvany, 1335 Carls Thor, Dusseldorf, Rhine, Prussia; Mr. P. Cooper, Grange Colliery, Durham.

The CHAIRMAN then referred to the papers standing for discussion, but observed that, in consequence of the absence of the President, Mr. Thos. J. Taylor, and some other members, he thought it better to postpone them until next meeting. In the meantime, Mr. J. Bewick, of Grosmont, would read a paper.

Mr. BEWICK, before proceeding with the paper, begged to observe that, before writing his paper, he had not had an opportunity of reading the one read some time ago by Mr. Marley on the Cleveland ironstone.

The paper with the discussion only reached him on Saturday, and, in consequence, he had no opportunity of referring to the paper of Mr. Marley as he proceeded. However, after carefully reading it along with the discussion, his conviction with regard to the original deposit of iron ore was as unshaken as before the document was produced. He then read the paper on the "Ore and Ironstone of Rosedale Abbey."

The CHAIRMAN said the meeting was much obliged to Mr. Bewick for his interesting and valuable paper, but, in accordance with their rules, the discussion of it must be brought on at some other meeting.

The meeting then broke up.

THE PRESIDENT'S PAPER ON THE CONVEYANCE OF COALS UNDERGROUND.

In this paper which was read before the Institute on February 5, 1857, at page 66, 6th line from bottom, *for* "And as the 4th is no doubt the cheapest," &c., *read* "And as the 3rd."

REMARKS

ON THE

ORE AND IRONSTONE

OF

ROSEDALE ABBEY.

By MR. JOS. BEWICK.

After having had so recently brought before you, by Mr. Marley, an able and full account of the ironstone of North Yorkshire, it may, perhaps, be considered that any additional contribution on this subject is superfluous and uncalled-for.* I, however, have thought that a further, though brief, account of the ore and ironstone of Rosedale, at a time when it is engaging so much of the attention of the mining and iron manufacturing community, might not be unacceptable to the members of this society. I have, therefore, been induced, after bestowing much pains in personally examining that singularly interesting deposit, the magnetic iron ore, as well as the ironstone of the district, to lay before you the result of my investigations.

I have been more particularly urged to do this from the circumstance of Mr. Marley, in his paper, making the following remarks in reference to this ore, that "the most feasible solution being that it is a disjointed patch of the regular seam, known as the top seam, and not a vein, as has been said," feeling quite sure that if that gentleman had had time to make a more careful examination of it, he would have arrived at a different conclusion.

This iron ore, which has of late created so great a sensation amongst

* I may just mention that when this paper was written the discussion on Mr. Marley's paper had not reached me, which will account for its not being referred to here.

our geologists, ironmasters, and mining engineers, is found in one of those beautiful and secluded dales for which the moorland districts of North Yorkshire are so celebrated, known by the name of Rosedale, being near to the village of Rosedale Abbey, situated about ten miles to the north-east of the town of Pickering, and about sixteen miles to the south-west of the port of Whitby. The extraordinary excitement which the discovery of this iron ore created arose not only from its great thickness and rich quality, but also from a large portion of it being in its natural state easily attracted by the magnet. Although I had long heard this peculiar deposit much talked about, and wonderful accounts from time to time reached me as to its amazing thickness, extent, &c., it was not till June last that I was induced to visit it. This apparent indifference on my part may be accounted for from the fact of my having previously examined the most of the dales where the lias formation is fully developed, and had arrived at the conclusion that out of the two chief ironstone deposits which it contains, only one was of any real commercial value, viz., that found in what is locally termed the marlstone series, identical with the thick bed of Cleveland; the other, which I thought was the one they had discovered in Rosedale, found intervening the alum-shale and sandstone rock, being, in my opinion, too coarse and silicious to be used alone advantageously in the manufacture of iron. On visiting the quarry where the ore is at present worked, near to the village of Rosedale Abbey, I was immediately impressed with the striking analogy it bore in its aspect to our basaltic dykes, and a further examination at once led me to the conclusion that it was of igneous origin—in fact, that it was neither more nor less than, as I firmly believe, an extensive volcanic dyke of iron ore. This opinion, I know, is at variance with that of many gentlemen possessing great practical experience, as well as scientific acquirements. It was not, however, till I had possessed myself of proof sufficiently convincing and conclusive, as I thought, that I arrived at this opinion. The proofs afforded me are, first, its vertical or unstratified formation; secondly, from its containing no organic remains whatever; and, thirdly, from its being highly susceptible to magnetic influence, as well as exhibiting the appearance of its having been in a state of incandescence.

With evidence such as this to guide you, I cannot see how any other conclusion can be come to than that this iron ore has been produced by volcanic action. The extent of this vein—whether of considerable extent or otherwise—cannot at present be ascertained. This can only be revealed to us by actual experiment. By the side of the valley where it is exposed

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SAN
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ASTOR LENOX AND
TILDEN FOUNDATIONS

Plan

REMARKS ON

ROSE

by

Iron Ore

Shale

Ironstone (good)

Ironstone (coarse)

Ironstone (moderate)

300 2

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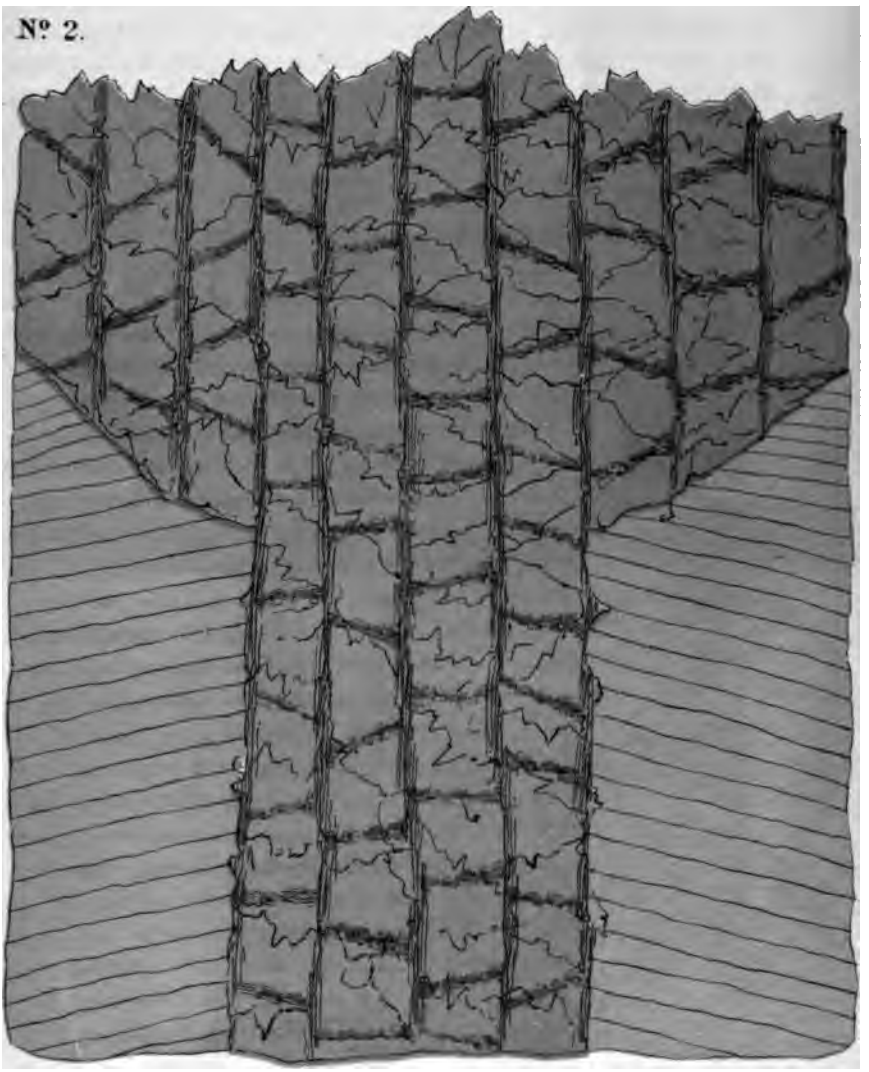
SECTION OF THE DYKE.



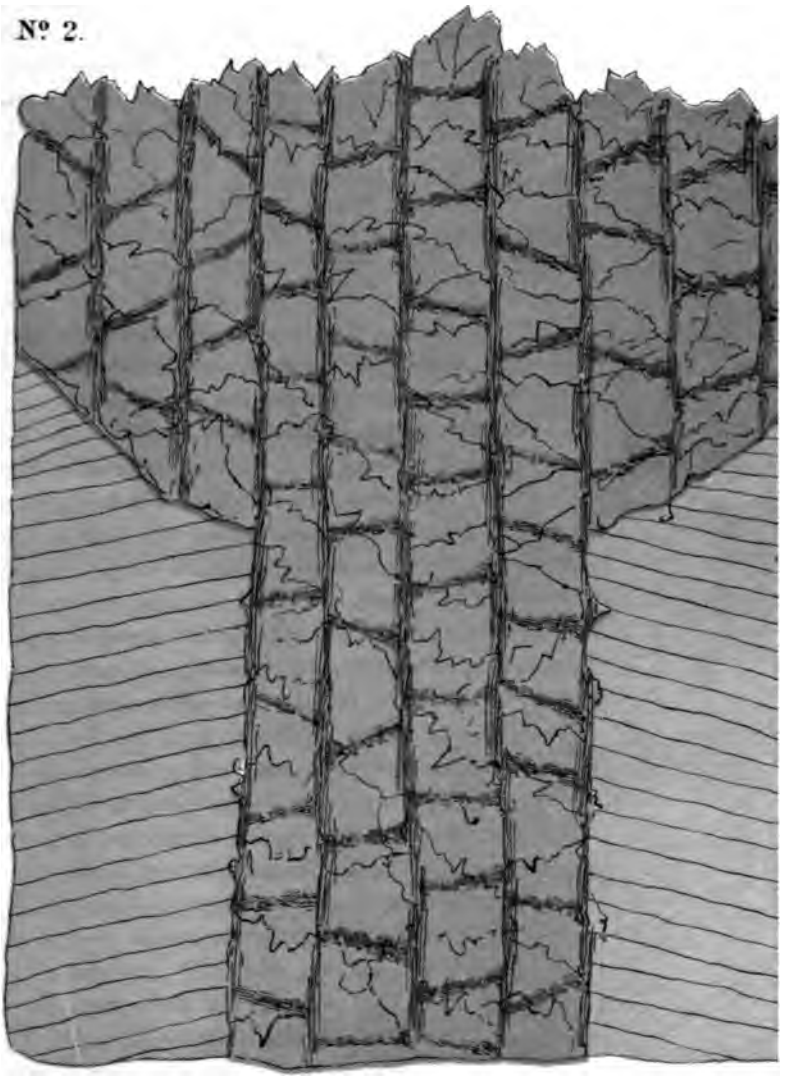
[illegible] Newcastle.

to view, it is traceable, apparently, for a distance of 300 or 400 yards, but as it is nothing but a confused mass, thrown together without either order or regularity—just, apparently, as it has been ejected from the interior of the earth—it is impossible even to guess at its breadth. The probability is that the mass, on reaching the surface of the earth, spread itself over the ground on both sides of the vein, and present appearances further the supposition that the vein becomes narrower in the downward direction, as, in excavating the quarry which is opened out on the north side of the dyke, the shale against which the ore rests forms an angle or slope, something like that represented in diagram No. 2. The valley, too, as far as we can judge, apparently intersects the vein in a diagonal direction, which, of course, will expose a much more extensive face than if it had been intersected at right angles.

I again visited Rosedale on the second and ninth of last month (November) for the purpose of seeing what progress had been made with the experiments now going on, and also to inspect some ironstone which has lately been opened out there; and in order that I might ascertain accurately what had been done in their subterraneous explorings in the vein, I took with me my circumferentor, and, with the sanction of the overlooker, made a survey of the workings, a sketch of which is represented in diagram No. 1. I found they were driving the drift in the heart of the vein, and apparently in a direction parallel to it. It had then reached the distance of 193 yards, and I was told they were about to commence at the face of the present two other drifts running at right angles from it, with a view of ascertaining its breadth, and until those trials be completed nothing further in the shape of information can be obtained beyond what is already known. The drift is six feet high and seven feet wide, and is let at 30s. per yard, one yard producing about nine tons of ore. This information was of some importance to me, as I gathered from it this fact, that whilst a portion of this ore is much heavier than the ordinary ironstone of the Grosmont district, yet in bulk it is somewhat lighter than the stone I am at present working in the mines under my charge, for it will be seen from the product just given that it takes 14 cubic feet to each ton of ore, whereas it only takes 13 feet to produce a ton of our stone, thus shewing that there must be a large portion of extraneous matter mixed with this ore of very little value. I was also anxious to ascertain whether there was any visible magnetical disturbance produced by this vein on the needle of the circumferentor, and in proceeding with my survey I soon found this to be the case, for on taking the angle between A and B, a distance of only

SECTION OF THE DYKE.

Nº 2.



Andrew Reid, lith. Graphor, Newcastle.

to view, it is traceable, apparently, for a distance of 300 or 400 yards, but as it is nothing but a confused mass, thrown together without either order or regularity—just, apparently, as it has been ejected from the interior of the earth—it is impossible even to guess at its breadth. The probability is that the mass, on reaching the surface of the earth, spread itself over the ground on both sides of the vein, and present appearances further the supposition that the vein becomes narrower in the downward direction, as, in excavating the quarry which is opened out on the north side of the dyke, the shale against which the ore rests forms an angle or slope, something like that represented in diagram No. 2. The valley, too, as far as we can judge, apparently intersects the vein in a diagonal direction, which, of course, will expose a much more extensive face than if it had been intersected at right angles.

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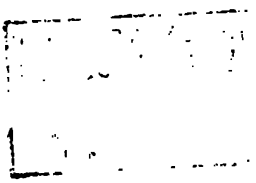
25 feet (previous to this there was no variation), I found the direction to be *North 87° West, and on removing my instrument to B, and taking the back sight to A, I found instead of the needle indicating North 87° West, it stood at North 6° East, shewing a variation of 9° in an easterly direction. It then became necessary for me, in completing my survey, to fix the needle and read off the angles by the vernier. This dyke appears to be traversing the district in a westerly direction, trending a little to the north, and it is a singular fact that it has never yet been traced beyond the locality where it is found, that I am aware of. It is more than probable, however, that a closer examination will discover it in the districts both East and West of Rosedale.

Judging from what has been advanced with reference to this vein, especially as regards this locality, we are naturally led to infer that any considerable quantity of ore is not likely to be obtainable from a field so limited in its extent as this appears to be—I mean, of course, its daily produce—from the great difficulty there would be of placing a large number of workmen in a mine so limited in its area. The working too of this ore, which is of a very hard and compact character, must be costly when compared with the ironstones of Cleveland, Grosmont, and other districts; and I cannot avoid expressing my belief that the commercial value of this mineral has been overated. Diagram No. 2 gives you some idea of the position in which this ore is found, though its shape, of course, is partly ideal.

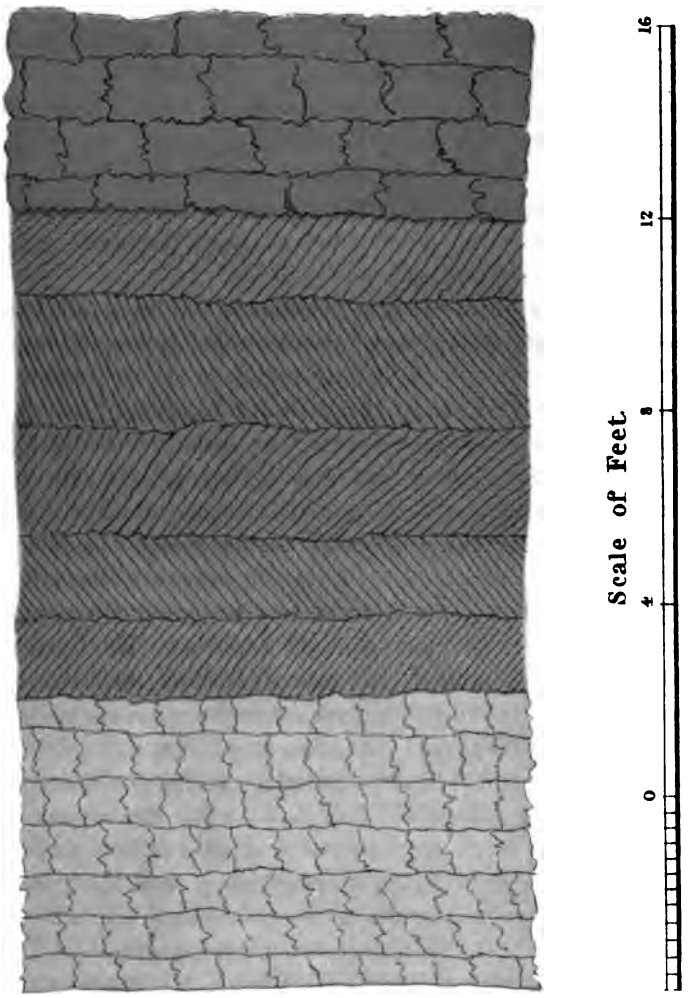
On the other side of the Vale, and a little to the north of the dyke, is seen, high up in the hill, and skirting the side of the valley, a thick seam of ironstone, the features of which much resemble those of the ore, and many are impressed with the belief that they are one and the same deposit. This, however, it is clear to me, is the same bed which I have taken the liberty of designating the top seam of the lias formation, and which, as I have already stated, intervenes the alum shale and sandstone rock, and a single glance of the experienced eye will at once detect the difference between them. This bed is very irregularly diffused throughout the whole of the lias district of North Yorkshire, varying very much both in quantity and quality. In some places you find it only a few feet thick; next you meet with it swollen out to the enormous thickness of fifteen or twenty feet; then, again, entirely wanting. In some places portions of it are of an average quality, but, generally speaking, it is too strongly impregnated with sand to be used, as I before stated, extensively in iron making. Diagram No. 3 is a section of the thickness of this seam of iron-

* The direction of the back sight being, of course, South 87° East.



Section of the Ironstone.

No. 3.



stone, as seen in "Northdale," about two miles to the north of Rosedale Abbey, the property of Capt. Vardon, where it is no less than twenty feet thick. Four feet of the top part of it appears rich in iron, and six feet of the bottom part of middling quality, and the middle portion very coarse indeed, samples of which I now produce. It is again met with in "Hartoft Vale," about two miles to the south-east of Rosedale Abbey, where it has been lately opened out, and although there is a great thickness of it there also, only about three feet of it appears to be of average quality. This stone is at present worked by Messrs. Palmer & Co., Messrs. Seymour & Co., and the Eskdale Ironstone Co., on the beach north of Whitby, and by the Whitby Iron Co. and the Murkeyside Mining Co.,* in Goathland, about eight miles from Whitby, joining the Whitby and Pickering Railway, and is at present engaging the attention of various other parties.†

Mr. Marley appears to have an objection to this being called the "top seam," and as I think it of some importance that a correct understanding should be come to as regards the nomenclature of the ironstone series, in a district so important as that of North Yorkshire, I may just state that my reason for designating it the "top seam" of the lias formation is simply from the fact of that rock containing only two workable deposits of ironstone, and that the strata immediately above it comprises another and distinct class of rocks, the one being a marine, and the other a terreous deposit, as their organic remains abundantly testify. The latter, in fact, being those which may be termed the carboniferous series of the moorland districts of North Yorkshire. This being the case I think it is much better, for the sake of avoiding confusion, that the ironstones found in these strata should be classed according to the respective situations they occupy in the series they belong to.

My object in thus troubling the members of this Institution with the foregoing remarks is twofold. First, to shew that the iron ore of Rosedale, instead of being a large mineral field, as was first asserted, and still believed to be so by many, is nothing more than a volcanic dyke; and, secondly, that the ironstone lately opened out in this locality is not, as it is reported to be, the main seam now being worked in Cleveland and Grosmont districts, but is in my opinion, if Mr. Marley will permit me to say so, the top seam.

Public attention having been so much drawn to this district, and that

* This company have closed their workings since this was written.

† An analysis of this stone, as well as the ore, with a map of the district, having already been given by Mr. Marley, it is only necessary for me to refer those who may wish for this information to his paper.

to a much greater extent than any other since the Cleveland discoveries, it may not be amiss, in conclusion, to glance at the prospect it holds out to speculators in iron mining, and the advantages to be derived from it generally. There is nothing so likely to attract as that which has something of the wonderful to recommend it, and this, I think, may very properly be applied to Rosedale.

The announcement that inexhaustible quantities of iron ore had been found in this valley, a large portion of which was not only richer than any yet discovered, but was also termed highly magnetic, was so startling an occurrence, as to stamp the locality, in the eyes of a portion of the mining and iron manufacturing public, as the one of all others that would, in all probability, yield the cheapest and best mineral. It was, therefore, not to be wondered at that people from all quarters should flock to it, in order to examine what may be considered little less than a geological phenomenon. Since, however, it has been found that this ore is restricted within much narrower limits than was at first expected, its aspect has become very much changed for the worse, and it now remains to be seen whether the extent of it is sufficient to warrant the making of a railway, without which it could never be profitably worked, failing which, I am of opinion the ironstone of this district must remain some time longer undisturbed, without other markets than those of the north can be found for it. I understand, nevertheless, a survey of a proposed line of railway has already been made, which, it is intended, shall form a junction with the North Yorkshire and Cleveland Railway, the construction of which, however, will, no doubt, as I have already said, depend upon the extent of the dyke. This once ascertained, the quantity it contains will be a mere question of calculation. It is true they have enormous quantities of the top seam in this district, a large portion of which appears to be of fair average quality, but it must be remembered that in the event of this railway being made, which Mr. Marley tells us will be about fourteen miles in length, it will, in all probability, open out in its route other fields of this stone, quite as well situated for working as that in Rosedale, and, being so much nearer a market, will, of course, be disposed of at a lower figure. This district being the point furthest south where the lias ironstone has yet been discovered, viz., within ten miles of the Whitby and Pickering Railway, at the town of Pickering, the idea naturally suggests itself that the iron districts of the West Riding of Yorkshire would afford the best market for this mineral, at any rate, it must be apparent to every one who knows anything of the neighbourhood, that it is not very favourably situated for competing successfully with some other districts in supplying the markets of the north.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, FEBRUARY 4, 1858, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

EDWD. POTTER, ESQ., ONE OF THE VICE-PRESIDENTS, IN THE CHAIR.

Mr. GORDON, of Gateshead, exhibited a model of a pump fitted up with Perreaux's patent India-rubber valve, and several experiments were made by members present with a view to test its efficiency.

Monsieur François Laurent, of Paris, was introduced by Thomas Bell, Esq., and exhibited a tracing illustrating a scheme for the ventilation of mines, which he had patented. Mr. Bell gave a brief outline of the scheme, pointing out its principal features, and it was understood that M. Laurent had prepared a short paper upon the subject, but as the rules of the Society confine the reading of papers to members, it was decided that beyond accepting lithographed drawings of the scheme, the Institute could not move in the matter. M. Laurent then intimated his wish to be enrolled as a member, and was proposed accordingly.

The CHAIRMAN, on taking his seat, expressed regret that the meeting was not honored by the presence of the President of the Institute. It was, however, satisfactory to know that his absence was occasioned not by illness, but by a pressure of business, which obliged him to leave home. The first business before the meeting was the election of new members.

The minutes of the last meeting having been read and duly confirmed,

The SECRETARY read the names of the following gentlemen, who were thereupon unanimously elected members of the Society, viz. :—Messrs. A. Davison, Hastings House, Seaton Delaval; and James and William Vaughan, Middlesborough.

Mr. H. T. PLEWS then read his paper "On the Coal Field of New South Wales;" after which,

Mr. H. LONGRIDGE asked Mr. Plews if he found any limestone in the locality which he had visited?

Mr. PLEWS said a carbonaceous limestone was found up the Williams river which might ultimately be found to have a connection with the fossiliferous sandstone. At present, however, that was not proved.

Mr. PLEWS said, in reply to another question from Mr. H. Longridge, he found no sandstone comparing with our millstone grit.

Mr. M. DUNN—Did you meet with any magnesian limestone?

Mr. PLEWS—None whatever.

Mr. DUNN—Is there any cannel coal?

Mr. PLEWS said some was found and worked at Stoney Creek. He thought it was the coal changed by dykes. The whole country was very much disturbed and broken up by dykes.

Mr. DUNN—Did you see any blind coal?

Mr. PLEWS—None.

The CHAIRMAN—The basaltic dykes seem to be all vertical?

Mr. PLEWS—Yes, they are, or nearly so.

Mr. T. Y. HALL—Is the coal generally bituminous? Does it produce more ash than ours?

Mr. PLEWS—Yes, a little more ash. It is the same coal in appearance as ours—a sound, bright, free-looking coal, but of course it does not contain the same constituent parts.

Mr. PLEWS said, in answer to a question from Mr. Dunn, competition was very much needed in the colony.

The CHAIRMAN said the seams appeared to be very thin.

Mr. PLEWS—They were so, generally.

Mr. PLEWS said, in reply to further questions, the Australian Agricultural Company for a long time had a monopoly of the trade in the colony. The cost to them of working the coal was something like 10s. to 11s. per ton, but a new company which had been started, called the Newcastle Coal and Copper Company, could work it for 9s. or 9s. 6d. per ton.

Mr. BOYD—Labourers' wages are high in the colony, I suppose?

Mr. PLEWS—Yes, the men get from 4s. to 5s. 6d. per ton, and a good workman can now make his 18s. to £1 per day. When I first went out there, some of them, good workmen, were making as much as £2 a day, and they seemed as if they did not know what to do with their money. They used to spend it in the most absurd way. Some, working at Four Mile Creek Pits, had just been paid, and so utterly at a loss were they

for fresh means of spending their money that they actually bought a dozen of champagne and washed their feet in it. (Laughter.)

The CHAIRMAN remarked that the aggregate yield of coal did not appear to have increased very rapidly.

Mr. PLEWS, said it increased rather suddenly at the period of the gold discovery. As soon as gold was discovered in California, vessels were sent to Australia for coal, and this caused an augmentation in the yield. But there were no appliances for assisting them in getting a further vend, and they were obliged to set to work to get railways laid down.

The CHAIRMAN asked if coals were used in the ocean steam-boats there?

Mr. PLEWS said they were, in the colonial steam-boats. The European Royal Mail Company used Welsh coal, but they had found that it did not answer so well as they expected, from having fallen to dust so much in the passage.

Mr. DUNN—What is the date of the grant to the Agricultural Company?

Mr. PLEWS—About 1825. It has been a badly managed company throughout.

Mr. DUNN asked if a Mr. Henderson had not the management of the Company's mines?

Mr. ANDERSON—He was sent out by Mr. Thomas Easton.

Mr. PLEWS said, as long as Mr. Henderson was at the head of affairs the pits were opened out in a proper manner and the trade prospered, but he died a few years after he went out, and since his death everything had been badly conducted.

Mr. DUNN—What is the name of the present manager?

Mr. PLEWS—A gentleman has just gone out to take charge of the mines. The late General Superintendent of the Company was a Captain Brownrigg.

Mr. BOYD—Had you any reason to suppose, from meeting with these fossils in the argillaceous sandstone, that you were approaching the old red sandstone?

Mr. PLEWS—It is the opinion of several eminent geologists that the coal may belong partly to the Devonian, but, with the exception of one or two fossils, common both to the lower carboniferous and to the upper old red sandstone, there is nothing to justify this opinion.

Mr. HALL—What is the largest quantity of coal produced in one year?

Mr. PLEWS—The last returns were published in 1855, when the production was about 200,000 tons. Last year the vend was about 5000 tons per week, giving a total yield of 250,000 tons from the whole of the collieries. That is the vend at the shipping shoots.

Mr. DUNN—I suppose they don't screen the coals?

Mr. PLEWS—They have screens but they are very often dumb. The trade has not been much fostered.

The CHAIRMAN—By the "shoot" you mean the shoot into the ship?

Mr. PLEWS—It is the loading place.

The CHAIRMAN—There are no harbour charges, are there?

Mr. PLEWS—No; no charges or dues whatever.

The CHAIRMAN—Is the competition considerable?

Mr. PLEWS—No, not sufficiently so.

Mr. DUNN—Is the royalty rent-free?

Mr. PLEWS—The rent at the Newcastle Coal and Copper Company's Mines was 2s. per ton, but the Company having amalgamated with private parties holding royalties under the same lessor, the lessor himself became a partner in the concern, with the arrangement that he gets one quarter of the profits, with a certain rent of £3000 per annum.

Mr. PLEWS said, in answer to Mr. DUNN, the above-mentioned land was originally granted to a person named Scott, who was obliged to sell it. The usual terms of lease were 1s. to 2s. per ton on the workings, and a lease of ten to twenty-one years.

Mr. HALL—Do they expect they will get it cheaper in that way?

Mr. PLEWS—I don't know what their idea was, but it was a most extraordinary one.

Mr. HALL—Did the lessees force the lessor to take one-quarter, or did the lessor force the lessees to give it to him?

Mr. PLEWS—I cannot tell, of course, the arrangement, but I believe the lessor forced the lessees.

Mr. BERKLEY asked if the government were not working the coal for their own use?

Mr. PLEWS—No, and have not for many years.

The CHAIRMAN said, he was sure there could be but one opinion upon the paper that had just been read. It was a very interesting paper indeed, and relating to so remote a part of the world, could not fail to prove a valuable addition to their published proceedings. The talent displayed in it entitled Mr. Plews to the highest credit, and he thought the thanks

of the Institute were justly due to him. He begged to move that the Society tender Mr. Plews its thanks for his interesting paper.

The motion was unanimously agreed to.

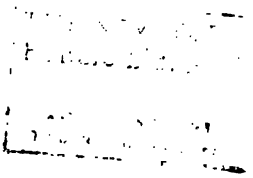
Mr. PLEWS, in acknowledging the compliment, said, he had to apologise for having been a member of the society so long without having contributed to its literature, but the fact was that when he was in Australia, probably owing to defective postal communication, he received no tidings of the society and never saw its published Transactions. The various parts were sent to his friends, by whom they were regularly transmitted to Australia, but by some mishap they never reached him, and he merely knew that the society was still existing.

The CHAIRMAN—How long were you away?

Mr. PLEWS—I have been absent above four years.

The SECRETARY said the parts had been regularly sent to Mr. Plews' relatives.

The meeting then broke up.



PLAN Nº 5

ON THE

COALFIELD OF NEW SOUTH WALES.

By MR. HENRY T. PLEWS.

When the pioneers of Australian emigration arrived within sight of their "promised land," the first object which met their eyes was a range of high land, apparently like a continuous chain of mountains, looming, blue and indistinct, in the distance. This range they named, not inaptly, the "Blue Mountains." On their arrival in the magnificent harbour of Port Jackson, these hills were found to be at a distance of about thirty-five miles inland from the coast at that point.

In the course of a few years, when their flocks and herds had increased, and they found that it would be necessary to penetrate further into the country in search of more extended pasturage, these hills formed an obstacle to their further progress, that, for a period of twenty-five years, i.e. till 1813, could not be overcome.

This range of hills, rising in several places to 5,000 feet, and in one part—Mount Kosckiusko—to 6,500 feet above the sea level, is the great Australian Alps or Cordillera, and extends not only along the whole line of the east coast of New South Wales, but is found continuous in Van Diemen's Land, or Tasmania, to the south, and in New Guinea to the north.

It is principally on the western slopes of this range, and of its advanced spurs, that the gold is found which has given this "Land of Ophir" such a prominent place in the annals of the world's history.

This chain has an axis of granite, passing into syenite and diorite, with greenstone and porphyritic, and amygdaloidal basalt and quartz.

These, with the metamorphic rocks, compose the great extent of the chain; but at that portion of the chain near Sydney, called the Blue Mountains, the sandstone, which has received among geologists the distinctive name of the "Sydney sandstone," and which flanks both sides of the chain, is elevated (the granite and other igneous rocks not bursting through), and forms a large plateau or table land, about forty miles across. At the foot of the abrupt and precipitous escarpment, near Penrith, formed by this upheaval, where its height is from 1,200 to 1,400 feet, the argillaceous coal shales, which have been elevated coincident with the sandstone, may be seen cropping out.

Flanking this Cordillera, on both its eastern and western sides, are the thick beds of the Sydney sandstone, superimposed upon the coal measures.

THE SYDNEY SANDSTONE.

This sandstone is the prevailing characteristic feature of Australian geology, and covers, according to Sir Thomas Mitchell, 6-7ths of the whole surface of nineteen counties, from Yass Plains on the south to the Liverpool range (the name given to the Cordillera in the Hunter River district and the north,) on the north, and has been, since his exploration, found to extend still further. The description of this sandstone is thus given by Dana:—It is a soft friable rock, of fine texture and light sandy colour. It consists of minute grains of quartz, with particles of decomposed feldspar of an opaque white colour, and scales of light-coloured mica; the quartz usually predominates. The colours of the layers are white, grayish white, and yellowish like ordinary sand, also varying to light blue, and grayish blue at Parramatta: there are also reddish shades. The colours are very often arranged in curved parallel bands or waving lines, and concentric oval figures. Iron ore, in the form of sand, is common, and it also occurs in seams. The disseminated iron is so abundant that exposure to the air and moisture soon rusts or reddens the surface, staining the rock to a depth of some feet. Magnetic iron sand is met with along the road sides and on the sea beaches.

Wherever this sandstone prevails, most of the water—north, south, east, and west—is brackish. The prevalence of salt springs is a predominant character of the inland waters of Australia, more than half the wells sunk being brackish.

Many of the northern tributaries of the Hunter, and of the Darling, west of the Blue Mountains, are brackish.

PLAN

OF A PORTION OF

NEW SOUTH WALES

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There are some accredited instances of the discovery of mineral salt in the sandstone. Some of the salt lakes in the interior have their waters denser than the ocean, and their shores are covered with plants peculiar to salt regions.

There are occasional beds of conglomerate in this sandstone, and at Woolongong (Illawarra district), and Newcastle (Hunter River district), where the coal measures appear, the superincumbent stratum, which, apparently, is composed of the lower beds of this sandstone, is almost entirely a conglomerate of quartzose pebbles, of various colours, with pieces of lignite, coal, and ironstone, cemented together with sand and the oxide of iron.

To the west of Sydney, and between it and the Blue mountains, this sandstone is depressed, and forms a small basin, through the centre of which flows the South Creek; this basin is filled in with a mass of shales and calcareous grits and sandstones, the lower beds intercalated with thin streaky layers of coal, as at Camden, George's river, &c., and these attain a thickness of about 800 feet. Stigmaria, sigillaria, coniferous wood, and various species of pecopteris have been found in these shales, and at Wirionil, near Campbeltown, the Rev. W. B. Clarke discovered, in blue shale immediately over the Sydney sandstone, casts of heterocercal ganoidal fish, and casts of the intestines of sauroidal and other fish.

Induced by the appearance of these shales, the Australian Agricultural Company, more than twenty-five years ago, put down a bore-hole near Parramatta, on the banks of the Parramatta river, a depth of 300 feet, in the expectation of finding a workable seam, which would have been extremely valuable within so short a distance of Sydney, this they did not succeed in finding, and it is evident that no workable seam exists above the Sydney sandstone.

ILLAWARRA DISTRICT.

Proceeding down the coast to the south a distance of about thirty-seven miles we find at Bullai *(vide Plan No.* 1*)* the underlying coal measures just appearing at high water mark, and, rising at an angle of four degrees, they stretch obliquely into the country and end at Mount Keera, near Woolongong, in an abrupt escarpment, about 1200 feet in height above the sea. The section attached to *Plan No.* 1, and the *Section No.* 1 *Plan No.* 2 (from George's river to Woolongong), show this escarpment.

There are here seven seams exposed to the day, the highest seam at

about 300 feet above sea level, overlying these are alternations of shale and sandstone, conglomerate and the Sydney sandstone. Immediately under the coal, and forming the foot of the hill, is a very argillaceous and concretionary sandstone of a light greyish blue, or greenish tint, this forms a gently undulating country about the town of Woolongong, and further to the south, near Kiama, is overlaid by the intruding basalt. Its plane of dip here is N.N.W. or N.W. This sandstone is comparatively rich in fossils, a list of which will be given hereafter.

The basalt overlying this bed has evidently been ejected while it was under the water and while the enclosed fossils were in a living state, as immediately under and in close conjunction with the basalt they are highly silicified, and they continue to be so for a considerable distance up the coast, gradually, however, losing that appearance as they recede from the basalt.

The coal of Illawarra is very inferior and far behind the Hunter River coal in appearance and quality. The following analysis is given by Professor Silliman, jun.—

Coke, or fixed carbon	65·125
Volatile carbon	15·850
Ashes	19·025
	100·000

Specific gravity ..... 1·439

There are three of the seams wrought by means of day drifts, to a very limited extent; the vend, with the exception of an occasional small shipment to Sydney, is entirely landsale, as the natural facilities for shipping the coal are very small indeed, there being no river nearer than the Shoalhaven, and the coast for a number of miles both to the north and south presenting no inlets which might be converted into safe and commodious harbours; the boat harbour of Woolongong, the principal sea-entrance and outlet to this district is only accessible to vessels of less than fifty tons, and is extremely small.

NEWCASTLE ON THE HUNTER RIVER.

Returning to Sydney, and proceeding from there up the coast, to the North, the Sydney sandstone presenting abrupt bluffs and headlands seaward all the way, we find the coal measures appearing some distance to the south of Reid's Mistake, as the South Headland of Lake Macquarie is named; the coal dips under the entrance to the lake, under

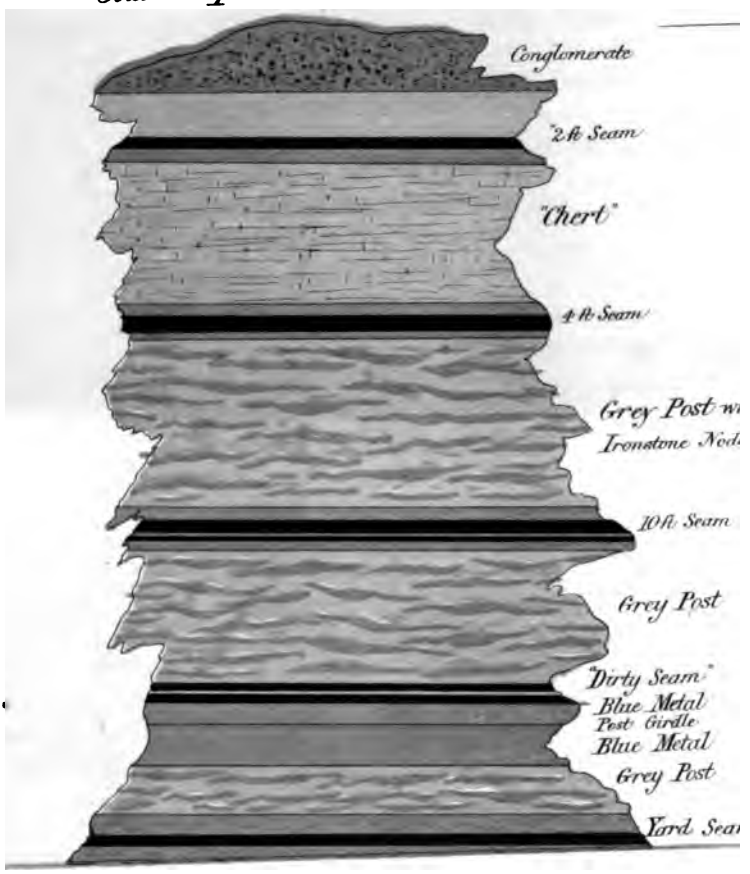
MECHAN

N Nº 2.

Khanterin

or

South "Shepherd's Hill"



Horizontal Scale 10 Chains per Inch

Vertical Do. 60 Feet . Do.

level, and under the North headland, which is composed of low sandy hills, and continuing, for about four miles further north, to run under these hills, it rises again at Redhead a high sandstone bluff abruptly thrown above the sandhills.

From here the coal seams continue exposed in the face of the cliffs, a distance of six miles further, *i.e.*, to the mouth of the river Hunter, but are much broken up and disturbed by faults and lateral pressures and upheaval, causing a series of undulations, the splitting of seams, and the running together of two or more.

At the highest point, Khanterin or South Shepherd's Hill, about half way, there are five seams exposed. *(Vide Plan No. 2, Section No. 3.)*

Standing out some distance from the mainland or Signal Hill, is Nobby Island, and between this and the Signal Hill, used formerly to be an entrance to the river, but the water being shallow and only admitting vessels drawing little water, a breakwater has been thrown across, thus allowing the whole volume of the river to pour through, and scour out the present entrance, between Nobby's and Stockton, or the North Mainland.

Two small seams (the 2 ft. and 4 ft. seams) are found on Nobby Island, and a trap (greenstone) dyke, throwing down these seams to the east three inches, passes through the middle of it in a S. E. and N. W. direction, coking the coal for some yards on each side of it.

The top stratum of Nobby Island *(vide Plan No. 2, Section No. 3)* is the quartzose conglomerate mentioned before, as forming the lower beds of the Sydney sandstone, the two-feet coal lies next, and immediately under it is a very peculiar fine white stone, ribbed or layered almost like a ribbon-agate, having a conchoidal fracture, with translucent edges; this, from its great resemblance to "chert," has received that distinctive name, but it is only an argillaceous shale, containing about 2 per cent. of silica, and has probably received its peculiar appearance from having been under water when the latter was highly heated by the eruption of the above and other dykes. This appears to me the most likely and the most feasible way of accounting for it, and the probability of it is strengthened by the fact, that this chert, which for several miles down the coast to the south, as well as for several miles inland to the west, continues to overlie the coal, and to hold the same position immediately inferior to the conglomerate, loses its cherty appearance gradually as it recedes from this dyke.

Crossing now the Hunter river from Nobby Island, we proceed along a coast line of low sandy dunes and ridges, until we reach the south headland of Port Stephen, and here we find the carboniferous beds thrown off to the south by porphyry.

Turning now to the west and proceeding inland towards Raymond Terrace, on the Hunter river, we traverse what we may presume to be the east line of outcrop of the Hunter river coal-field; as at Raymond Terrace we find a sandstone overlying silicious breccia, cropping out from under the bed of the river, presenting the same appearance and nature, and containing many of the same fossils as the sandstone which underlies the coal at Woolongong. *(Vide Section No. 2, Plan No. 2.)*

Further west again, and beyond West Maitland, the same sandstone is found at Harper's Hill, and the coal and it continue to be found at intervals, in the same relative position, all the way up to and on the flanks of the Liverpool Range, or Cordillera.

Most of the faults which dislocate and break up the seams between Nobby Island and Lake Macquarie, and all the greenstone and trachytic dykes from Nobby Island down the coast to Broken Bay, have a general direction of from nearly south-east to north-west, and in this direction the coal measures are, by upheaval, contraction, and lateral pressure together, folded up and down, in long or short undulations, so that the coal beds are alternately elevated and depressed, and the underlying rocks made to partake in similar changes, becoming prominent at points where the strata fold anticlinally, by which the lower beds seem to occupy an apparent position not actually belonging to them; the consequence of this is, that every few yards has its own peculiar dip, and it, therefore, becomes a matter of great difficulty, and, in most cases, with the few data, there exists, at present, from the scarcity of bore-holes, shafts, and wells, of almost utter impossibility to pronounce, with any certainty, the relative position which a seam found inland may hold with the rest in the coal measures. As, for instance, in the section from the coast inland *(Plan No. 7)*, there are at that particular point of the coast three seams, the top one overlaid by grey post and conglomerate; three-quarters of a mile, in a direct line inland (the section takes it obliquely and makes it a mile,) from the coast, however, all these three seams die out, and when we reach the *D*, or bore-hole pit, we find a seam totally unlike any of the above three, yet overlaid by the grey post and conglomerate, and no seam below it for a depth of 294 feet; it is, therefore, little more than

GLOSSOPTERIS BROWNIANA. NAT. SIZE.

a mere guess to say that this seam consists of the two lowest seams, the yard seam and the lowest seam in the *F* pit run together; this seam dips in almost every direction from the shaft, thus:—

At shaft	dips	4° S.W.
At the northermost part of the workings..	„	4° N.W.
At the south-west side	„	12° S.E.
And at the north-east side	„	7° S.E.

Then, again, at a further distance of about a quarter of a mile, or at bore-hole No. 2, this seam thins out to half its thickness; and at bore-hole No. 1, this and every other seam has totally disappeared. Still, when we reach the banks of the Hunter, we find a seam cropping out, nearly at the level of the river, of the same thickness exactly as this seam at bore-hole No. 2.

There can be no doubt that, after the undulatory movement above-mentioned had taken place, the valleys formed by the synclinal curves became large inland lakes, and extensive denudation and future silting up consequently followed. This is the only way in which I can account for the disappearance of the coal on both sides of the *D* and *E* Pits, and at other similar places.

This denudation and washing away of the synclinal curve of these undulations will, I am persuaded, be found to be pretty general, especially as we approach the river and the coast, and the most coal will continue to be found in the ridges formed by the anticlinal angle of undulation. This has hitherto been the case, as at Burwood, &c., &c.

FOSSIL FLORA OF THE COAL (*vide Plan No.* 3).

From the contrarieties which nature in Australia seems to delight in—in its existent botany as well as in almost everything else, its trees and plants being so totally different from those of any other portion of the globe that some of them shed their bark instead of their leaves—one would naturally be led to expect that the Fossil Botany as well would be completely dissimilar to that of other countries. This is, however, so far as the discoveries up to the present time have proved, only the case to the extent of some of the species being different; and although there is an extraordinary paucity of genera, species, and individuals, the sequence with which they appear in the geological formations discovers laws similar to those which regulated the succession of genera and species in other parts of the world.

The "glossopteris browniana" is, of the filices, the one most prevalent

in the coal. It is very abundant, and, I believe, it is characteristic of all the coal found in Australasia. The lanceolate leaf or frond of this fern is, at the first glance, so similar to the leaf of the "eucalyptus" or gum tree, that by many it has been taken to be the same, but on closer examination it will be found that the eucalyptus leaf has an intramarginal veinlet running up each side, which the "glossopteris" has not.

Count Strzelecki, in his "Physical Description of New South Wales," in comparing the New South Wales coal fossils to those found in the Burdwan coal field of India, states that the Australian coal fields are entirely deficient in the genera Sigillaria, Lepidodendron, Calamites and Coniferæ. This is certainly not the case, particularly as regards the two latter genera, which are comparatively common. The two former, it is true, are exceedingly rare, and I have not myself been able to find any specimens in the coal measures in the immediate neighbourhood of Newcastle that I could pronounce, with any confidence, to belong to those genera; but the Rev. W. B. Clarke states that he has discovered species of sigillaria and lepidodendron on the Paterson river, at Muswellbrook, and at Woolongong, and he further gives the following list of fossil flora:—Pecopteris, neuropteris, odontopteris, cyclopteris, sphenopteris, glossopteris, genus intermediate between tæniopteris and glossopteris, halonia, reed-like stems, calamites, phyllotheca, zeugophyllites, equisetum, lycopodites, new genus of plants with wedge-formed stems, lepidodendron, sometimes lepidostrobi, ulodendron, sigillaria and stigmaria, coniferæ: in all about sixty species.

With respect to coniferæ, there is at Redhead, six miles from Newcastle, the remains of a fossil forest on a broad bed of shale, uncovered at low water—the roots and trunks of the trees, some of them three feet in diameter, evidently in the situation where grown—completely converted into rich ironstone, partially hydrated by the action of the air and water. Three miles nearer Newcastle, there are a few more trunks; and at eight miles north-west from Singleton are the remains of another fossil forest, imbedded in the same description of rock as those at Redhead.

THE FOSSIL FAUNÆ (*vide Plan No.* 4).

The fossil zoology of the coal measures of New South Wales is also not very striking in the number of its genera and species. The following have been found in the argillaceous concretionary sandstone underlying the coal:—

At Harper's Hill.—Bellerophon, platyschisma, pleurotomaria, conu-

PLATYSCHISMA ROTUNDATUM.

MEDI

MEDIOLA CRASSISSIMA.

REID. N°1

laria, spirifer, solecurtus, mœonia, nucula, eurydesma, cypricardi pachydomus, chœtites, hemetrypa.

At Illawarra.—Pleurotomaria, natica, platyschisma, theca terebratula, productus, spirifer, solecurtus, cardium, pholadomy risma, astarte, astartila, cardinia, nucula, cypricardia, mœonia, e avicula, pecten, pterinea, chœtetes, pentadia (crinoidal), conul lerophon, pachydomus, orthenota, notomya, inoceramus, stepopo

At Glendon.—Conularia, spirifer, astarte, pholadomya, cy fenestella, nucula, avicula, and encrinital remains of one or two

In a grey post, about seventy feet below sea level, at Ne heterocercal ganoidal fish, similar to the one found at Campbell discovered.

EXTENT OF COAL FIELD.

The plane of dip of the coal measures in the Hunter River dis I stated before, exceedingly variable, from one degree to sixte and more, to nearly every point of the compass, caused by the locations, and the undulations mentioned above; but there ca doubt, after a due examination, that the general and mean d coal field is to the south, or perhaps a little to the east of sou dip at Raymond Terrace and at Nobby Island being to the south on the coast between Sydney and Broken Bay being westward dip of the seams at Illawarra being north west, the longitudin this basin is, therefore, most probably in a direction nearly nort south west, that is, nearly parallel with the escarpment of the Sydney sandstone, at the back of Woolongong; the Illawarra b on its eastern and the Newcastle beds on its western side.

The transverse axis in this case will run, as it ought accordi the physical conditions of the country, nearly through the mid County of Cumberland, and the trough or depression filled by shales and sandstones that is between the Hawkesbury river an Jackson estuary, the former occupying a line of faults continu the course of the Colo. The Hunter river also occupies a simil faults parallel to this axis.

The strike being thus north east, it is evident that there must siderable tract of coal measures washed away to the eastward Castle, or sunk by a downcast fault below the ocean.

The seams at Illawarra, dipping four degrees, must be the

curve of one of the before-named undulations, as if we take a dip of only one degree from Newcastle to the south, and from Illawarra to the north, the synclinal curve will meet at Broken Bay, which is exactly half way, at a depth of about 5000 feet, the depth of the seams if continuous at that angle. Now, as the coal shales, as stated before, are discovered cropping out in the deep valleys at the foot of the immense escarpment caused by the upheaval of the Blue Mountains, near Penrith, and as coal apparently identical has been discovered at the foot of Mount York, in the vale of Clwydd, 2100 feet above the sea, and as the computed greatest thickness of the Sydney sandstone, (which is, so far as has been yet discovered, immediately superimposed on and conformable with the coal measures,) measured at right angles to its dip, is 1200 to 1400 feet, it is apparent that a fault of great magnitude must exist, throwing the seams up to within 1500 or 1600 feet of the surface at Broken Bay.

Further discoveries of course may very much modify this view, or indeed prove it to be altogether erroneous, but in the meanwhile taking it to be correct, the full area of this coal-field lying to the east of the dividing range or Cordillera, will be about 15,000 or 16,000 square miles, *i.e.*, the whole of this area, except where the igneous rocks have burst through, is, in my opinion, occupied by the one contemporaneous series of carboniferous formation, the whole of it of course not being available.

Up to the present time, although boreholes have been put down to a depth of four hundred and fifty feet below high water mark at Newcastle, the number of consecutive seams found there at any one place has never exceeded six, giving an aggregate of about 19 feet, thus the depth of the coal measures is by no means great. At Mount Wingan, near Murrurrundi, on the eastern flank of the Liverpool range, where the coal cropping out, has at sometime spontaneously taken fire and is still burning, the fossiliferous sandstone of Harper's Hill, Raymond Terrace, and Woolongong, interpolate seams of coal, so that it is not improbable that seams may be found throughout the coal-field intercalated with or overlaid by this sandstone, and if this coal-field belongs to the same era as the independent coal measures of this country, which, in my opinion, there exists no sufficient reason to doubt, these lower seams will be identical with the seams of our mountain limestone.

If the depth of the Hunter river coal-field, however, is so slight in comparison with the coal-fields of other countries, the extent of country lying between the several extreme points where coal has been discovered,

AN Nº6.

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south, east, and west, and where the Sydney sandstone, existing surface stratum, it is not improbable the coal seams may be also ent throughout, is so enormous as to be second, I believe, only to al-fields of North America.

ill enumerate a few of the localities where coal has been found; a the Hunter river district; some distance south of Lake Macquarie, e Macquarie, Morpeth, Four Mile Creek, Hexham, Sugar Loaf s, Wallis's Creek, Stoney Creek, Anvil Creek, Black Creek, Purra, Glendon Brook, Tolga Creek, on the Paterson, Wollombi , Leamington, Wollon, Jerry's Plains, Sadleir's Creek, Junction of ook and Falbrook, Ravensworth, Maidwater Creek, Muswellbrook the old slate rocks burst through the coal), Edenglassie, Pierce-Bengala, Page's River, Murrurrundi, Kingdon Ponds, Mount n Wailand's Range, Scone, junction of Goulburn and Hunter , and in many other localities.

m Newcastle to the north, as far as the Mackenzie river, in 23° latitude (where coal, identical in its features with the Hunter coal was found by Dr. Leickhardt), the coal has been found y intermediate points, as at Port Macquarie, and on the banks of isbane river, Moreton Bay, (*vide Plan, No.* 8,) where it is worked mited extent, and as a sandstone similar to the Sydney sandstone at the Gulf of Carpentaria, in Torres' Straits, it is not improbable e measures continue further north still.

the south, four seams are also said to occur near Cape Paterson, and stern Port, in the Colony of Victoria. Coal has also been found stern Australia, Kerguelen's Land, and in New Zealand, the latter g the same distinctive features, and apparently holding the same ical position as the coal of New South Wales. In Van Diemen's now called Tasmania, the coal which is found and worked is known of the same age as the Hunter river coal. The following is an is of coal from the Jerusalem basin, Van Diemen's Land :—

Carbon	68·18
Hydrogen	3·99
Ash	19·20
Sulphur	1·12
Nitrogen	1·62
Oxygen	5·89
	100·00

AGE OF THE COAL.

I have now arrived at that portion of my subject which I approach with the greatest diffidence, as, among far more experienced geologists than myself, the geological age of the Australian coal-fields is still a "vexata quæstio."

The extreme paucity of fossil specimens in the Sydney sandstone make it a matter of much hesitation to pronounce its particular place in the geological series.

The ganoidal fish, with their heterocercal tails,* discovered in the sandstone, and immediately above and below it, being evidently permian in their type, and the existence of mineral salt inland, where the upper saliferous marls may exist, with the great prevalence of salt springs, certainly would lead us to infer that it belonged to the lower new red sandstone series. It is in its connection, however, with the coal measures, in conjunction with the above—the coal measures containing, as they do, so many of the fossils prevalent in the carboniferous epoch—that we first begin to feel more certain that this may be the case.

Little doubt can exist, after a careful examination of the fossil botany of the coal measures, in my opinion, as to the position which they hold in the geological scale, and as to the epoch they belong to.

The Woolongong, Raymond Terrace, Harper's Hill, Glendon, and Mount Wingan, fossiliferous sandstone, contains such a comparative abundance of carboniferous limestone fossils, that it remains only for us, with the present scarcity of data having reference to the underlying strata, in the meantime to suppose it to be the equivalent of, in New South Wales, and to hold the position of the mountain limestone of our own coal measures here.

COLLIERIES OF THE HUNTER RIVER DISTRICT.

In the former days of the colony, and while it was a penal settlement, a prison stockade was formed at Newcastle, and many of the convicts were employed in working the two lower beach seams (the Dirty seam and the Yard seam), by means of shallow pits and day levels, to supply

* One of these fish, found at Parramatta, is evidently a species of "palœoniscus," while another, found at Cockatoo Island, Port Jackson, I believe to belong to the genus "platysomus;" and another, found also at Cockatoo, has been named a "pygopterus." In consequence of the only specimen of the colony having been sent to the Paris Exhibition, and not having returned when I left, I am, unfortunately, unable to give a drawing of it.

fuel for the prison, and barracks, &c., at Newcastle, and the different Government offices, men of war, &c., at Sydney, and elsewhere in the colony.

In 1825, however, a London Company, which took the name of the Australian Agricultural Company, and which had received, on subscribing a capital of £1,000,000, a grant of the same number of acres, in New South Wales, on certain conditions, entered into negociation with the Home Government for the lease of the coal mines at Newcastle. In July, 1828, an agreement, by letter, was concluded, granting them, in lieu of the lease, 2,000 acres of land, containing coal, and immediately surrounding the city of Newcastle, with the understanding that the Government should receive the coals they required, which should not exceed one-quarter of the average annual produce at cost price, and, at the same time, gave them what was equivalent to a monopoly, by instructing the Colonial Government to retain all the coals, in any grants issued for the next thirty-one years. This monopoly, I may state, was annulled by the Legislative Council, in 1847, the Company having before had to complain of other parties working coal.

The Company first commenced to work the yard seam in the *A* Pit *(vide Plans Nos. 5 & 6)*; this has been long closed.

The following is the section of the strata in the *B* Pit, which was next worked:—

				Ft.	In.
Reddish yellow sandstone				17	0
Blueish grey post (soft)				15	2
Coal and shale mixed				5	0
Blueish grey post (soft)				10	0
COAL (Dirty Seam)	Bad coal	2	6		
	Sagger clay band	0	7		
	Bad coal	1	0		
	Good coal	1	8		
				5	9
Blueish grey post (soft)				24	0
Do. do. (hard)				6	0
Do. do. (soft)				0	6
Do. do. (hard, with impressions of glossopteris)				20	0
COAL (Yard Seam)	Bad coal	1	0		
	Good coal	1	6		
	Band	0	1½		
	Good coal	1	6		
				4	1½
				107	4½

Thill, hard blueish grey post.

After having wrought the Yard seam (the Dirty seam was here not worth working) to the extent which, with their appliances, they could in this

pit, they then sunk the *C* Pit, reaching the Dirty seam at 190 feet, and the yard seam at 212 feet; both these seams they worked, but having encroached upon the shaft pillars in the Dirty seam, the creep came on and this pit was also laid in.

The following are the sections of these seams in this pit:—

DIRTY SEAM.

	Ft.	In.
Top coal (not worked)	1	0
Good coal	0	6
Band, grey metal	0	2
Good coal	0	10
Sagger clay band	0	6
Good coal	0	4
Band, black clay	0	8
Good coal	1	6
Thill, blue metal.	5	6

YARD SEAM.

	Ft.	In.
Top coal, good	0	4
Band black metal	0	4
Coal, good	1	1
Black metal band	0	1
Coal, good	1	3½
	3	1½

The reason, by-the-bye, why one of the above seams is called the "Dirty Seam," is in consequence of the soft sagger clay band making the coals very dirty when wet.

Another pit has lately been sunk further south, (the *F* Pit), to work the Yard seam, to the south of the downcast faults, the following is the section:—

	Ft.	In.	Ft.	In.
Soil	3	6		
Reddish clay	4	0		
Sandstone, soft reddish	11	0		
Blue metal, with ironstone nodules	7	6		
Coal and shale mixed	4	0		
Greyish post	15	0		
Grey metal	4	0		
Coal	1	6		
Grey metal	0	6		
Blue metal, with numerous impressions of glossopteris and equisetuin and beds of ironstone	27	0		
Hard white post	8	9		
Blue metal	0	3		
COAL (Yard Seam)	3	0		
			90	0
BORED FROM HERE. Hard grey post	30	0		
Grey metal	1	6		
Coal	2	0		
			33	6
			123	6

This pit is still working, they are not drawing more, however, than about 100 tons per day from it.

The *D* and *E* Pits, (*vide Plan No.* 7,) are sunk on a ridge (the anticlinal curve), about two miles direct west from the *F* Pit. These two miles consist of a low level sandy plain, with a swamp in its centre. A short distance to the west of the *F* Pit, and under this plain, the yard seam comes very close to the surface, and thins out; the whole of the seams will, therefore, in my opinion, be found to be denuded, or, at least, so much deteriorated as to be worthless underneath, forming one instance of the synclinal denudation. There is a quicksand at a depth of about sixteen feet under this plain, which seems to have deterred them from sinking pits or putting down boreholes on it. It is probable that, from the strata above and below the seam worked in the *D* and *E* Pits, this seam has been formed by the Yard seam and the lowest one, run together here.

The following is the section of the strata sunk through in the *D* and *E* Pits:—

D OR BOREHOLE PIT.

			Ft.	In.
Clay			3	0
Conglomerate, very coarse			36	0
Blue metal, strong			7	0
Grey post, running into conglomerate			91	0
Blue metal			3	0
COAL—				
Coal, good	2	2		
Grey metal, with coal	2	0		
Coal, good	1	3		
Blue metal, with coal	1	0		
Coal, good	2	10		
			9	3
			149	3

Sump, grey post.

E PIT.

			Ft.	In.
Soil, light clay and stiff blue clay			9	0
White sand (dry) and red sand, with pieces of water-worn coal			3	0
Metal, with coal pipes			0	6
Blue metal			25	0
Grey post, hard			17	0
Ditto, scamy, in 1 in. beds			3	6
Ditto, changing into conglomerate			23	0
Conglomerate, with holes full of sand			14	0
Blue metal, with ironstone bands and nodules			24	0
COAL—				
Coal, good	3	0		
Grey metal, with coal	2	8		
Coal, good	0	10		
Blue metal and coal	0	8		
Coal, good	2	8		
			9	10
			128	10

Sump, grey post.

A borehole has lately been put down at the bottom of the *D* Pit, and at 294 feet 9½ inches from the working seam, reached the following seam:—

	Ft.	In.
Good bright coal	2	6
Band of coal and metal	0	3
Good bright coal	0	2½
Metal band	0	7
Good bright coal	0	7
	4	1½

Thill metal.

gave off salt water not containing 2 per cent., and gas burning with a blue flame, tinged with red.

These two pits are at present working, and the daily workings are from 200 to 300 tons drawn to bank.

Proceeding further west we find, at borehole No. 2, the same seam thinned out to half its depth. Section of the strata bored through in borehole No. 2:—

		Ft.	In.	Ft.	In.
5 feet staple.	Surface soil	1	0		
	Ferruginous marley clay	2	8		
	Sandstone, soft	0	3		
	Chertey sandstone, beds dipping S. 5°	1	9		
	Conglomerate	93	4		
	Mild grey post, with water	0	8		
	Conglomerate	25	5		
	Grey post	6	2		
	Blue metal, with coal pipes	8	9		
	Coal, good and clean	2	8		
				142	8
	Grey metal	0	3		
	Grey post	60	1		
	Blue metal, mixed with post	6	10		
	Grey post, very soft	2	0		
	Blue metal, mixed with post, left off in this	12	11		
				82	1
				224	9

The country to the west from here again becomes low, flat, and swampy for about one mile in that direction; and, therefore, at borehole No. 1, about three-quarters of a mile to the west of No. 2, the seams have entirely disappeared again. The following is the section of strata bored through:—

		Ft.	In.
Staple sunk and quicksand piled through.	1. Soil, black	2	0
	2. Clay, strong blue, with sand	6	0
	3. Sand, dark brown and hard	6	0
	4. Quicksand, with water 80 gallons per hour (*brackish*)	4	0
	5. Clay, very strong blue	16	0

		Ft.	In.
6.	Clay, very strong yellow	4	0
7.	Ditto, ditto white	2	0
8.	Sandstone, soft yellow	10	3
9.	Grey post, strong	36	0
10.	Ditto, scamy	7	9
11.	Ditto, very strong	2	0
12.	Ditto, scamy, very soft	2	9
13.	Blue metal, mixed with post, and three ironstone girdles at 61 feet (two of 2½ and one of 3½)	69	0
14.	Ironstone girdles, with post—four of them	1	6
15.	Blue metal, mixed with post	10	10
16.	Ironstone girdle	0	2
17.	Grey scamy post, with blue metal	6	10
18.	Black slatey stone, with *coal*	0	8
19.	Grey post, with blue metal partings	4	6
20.	Black stone, with *coal*	0	4
21.	Grey post, scamy, mixed with black metal	5	3
22.	Black metal, with coal	0	4
23.	Brown post, girdle very strong	0	8
24.	Grey post, mixed with blue metal	7	5
25.	Black slatey stone, with *coal*	0	3
26.	Blue metal	0	7
27.	Grey post girdle	1	2
28.	Blue metal, with coal pipes	6	6
29.	Brownish grey post girdle	0	6
30.	Blue metal	0	2
31.	Brownish grey post girdle	0	2
32.	Blue metal, mixed with post	2	10
33.	Blue metal	1	9
34.	Brown post girdle	0	3
35.	Blue metal	1	2
36.	Black slatey stone, with *coal*	0	3
37.	Blue metal	1	0
38.	Brown post girdle, very hard	0	8
39.	Blue metal parting	0	1
40.	Brown post girdle	0	3
41.	Blue metal mixed with post	5	11
42.	White post girdle	0	11
43.	Dark brown metal, with coal pipes	3	9
44.	Post, very mild	2	6
45.	Grey metal	5	8
46.	White fire-clay (chert?)	0	8½
47.	Blue metal, dark and hard	0	3
48.	Black slatey stone, mixed with coal	3	0
49.	Grey post, with coal pipes	1	11
50.	Grey metal	2	2
51.	White clay (chert?)	5	5½
52.	Blue metal, with coal pipes	1	6
53.	Blue metal	2	10
54.	Brownish grey post, scamy	3	7
55.	Blue metal	2	0
56.	Black shale, mixed with coal	0	10
57.	Grey metal	4	2
58.	Grey post, with coal pipes the last 8 inches, hard, and running into	6	1
59.	Conglomerate, very hard	0	8
	Parting of coal pipe	0	1½
60.	Conglomerate, very hard	1	0
61.	Blue and grey metal, mixed	5	6
62.	Grey post girdle	0	9
63.	Blue metal, with coal pipe	0	5½
64.	Grey post (with a few coal pipes and two metal partings)	10	9

	Ft.	In.
65. Blue metal and grey post, mixed	1	0
66. Grey post, changing into conglomerate, very coarse towards bottom	5	8
67. Blue metal, with coal pipe	0	11
68. Grey post and conglomerate	2	1
69. Blue metal	5	0
70. Post girdle (hard)	0	3
71. Blue metal	2	6
72. Post girdle (hard)	0	6
73. Blue metal parting	0	1
74. Post girdle (hard)	0	9
75. Blue metal	0	4
76. Post girdle (hard)	1	11
77. Blue metal	0	2
78. Post girdle	0	2
79. Blue metal, with post	4	9
80. Black slatey stone with coal	0	4
81. Blue metal, with post	4	6
82. Post girdle (hard)	0	3
83. Blue metal parting	0	1
84. Post girdle (hard)	0	2
85. Blue metal	0	4
86. Post girdle	0	3½
87. Blue metal	0	6
88. Post girdle	0	3½
89. Blue metal	10	1
90. *Coal*, good and bright	0	6
91. Blue metal, mixed with post	5	5
92. Grey metal	0	4
93. White clayey shale	1	3
94. Bastard whin	1	0
95. Blue metal	1	2
96. Post girdle	0	6
97. Blue metal	1	4
98. Post girdle	0	5
99. Blue metal, mixed with post	14	8
100. Blue metal, very strong	24	1
101. Soapy shale, greenish, like steatite	0	7
102. Blue metal	1	5
103. Post girdle	0	2
104. Blue metal	8	7
105. Soapy shale, "cherty"	1	2
106. Blue metal	35	0
107. "Cherty" shale	0	2
108. Blue metal, left off in	2	9
Total feet	439	9

Traversing the line of section (*Plan No.* 7), we arrive at a borehole that was put down many years ago by the Australian Agricultural Company, the account of which, if any was made, appears to have been lost, and I have not been able to obtain any information about it, further than after passing through a seam two feet eight inches in thickness, at a depth of twenty feet, they continued to bore, without finding any other, to a depth of 443 feet three inches, in alternations of metals and posts.

Crossing over the river we reach a borehole on Ash Island, of which the following is the section :—

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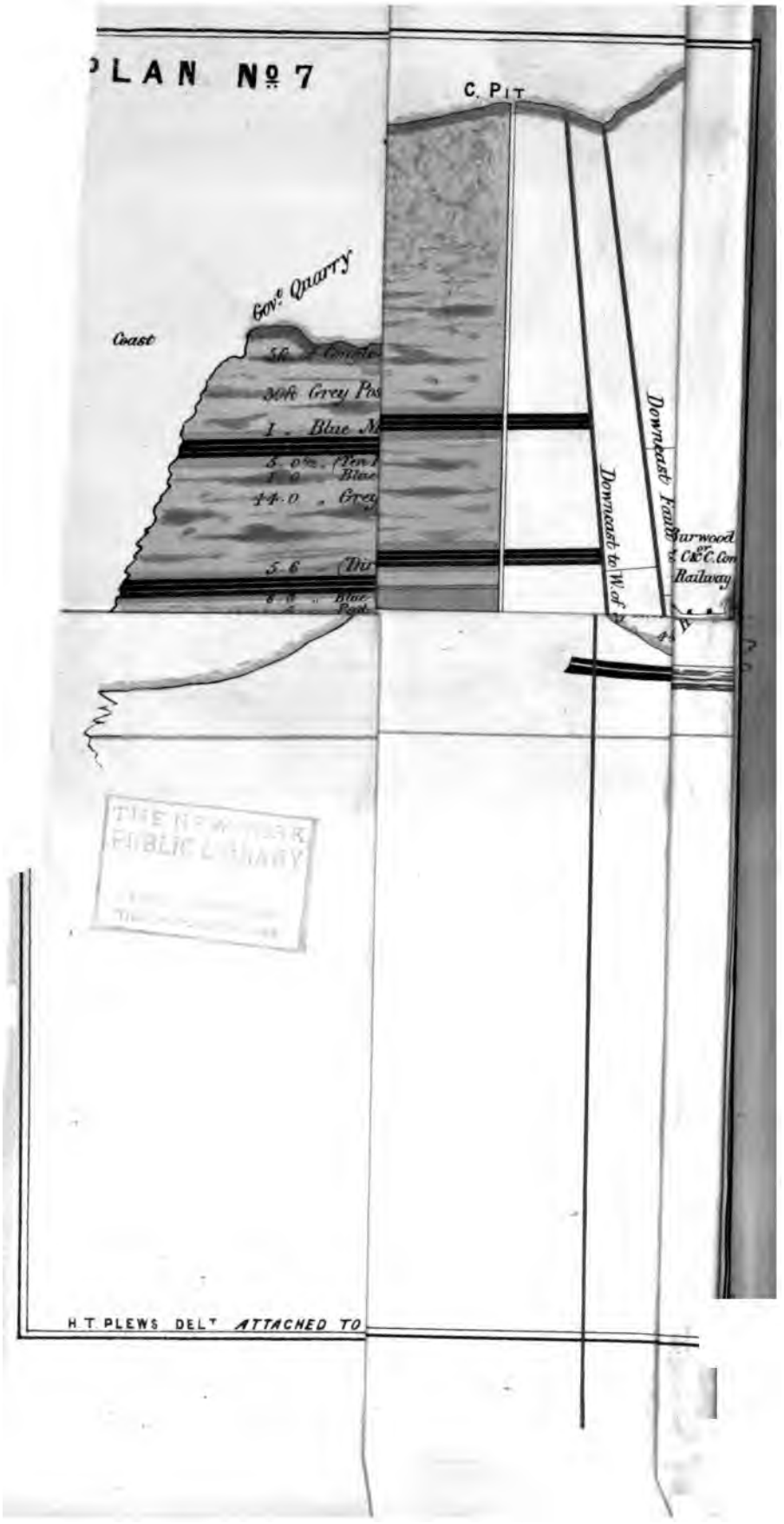
SAN FRANCISCO



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			Ft.	In.
1. Alluvial soil			3	0
2. Blue clay			3	0
3. Dark sandy soil with clay			6	0
4. Quicksand, containing the following marine shells, "mactia" semi fossil, "cardium," "cerithiam," "ostrea," "natica," "trochus,"			5	0
5. Sand (pure)			1	0
6. Do., with coal pipes and small pebbles of various colors, and shells			1	0
7. Sand (pure)			2	0
8. Ditto, white			7	0
9. Sand, rather darker			2	0
10. Ditto, with lumps of clay			0	6
11. Clay, dark and stiff			1	0
12. Ditto, stiff blue			0	6
13. Ditto, yellow			0	6
14. Sandstone			3	6
15. Ditto, with metal girdles and coal pipes			11	0
16. Coal	Coal	0 3		
	Band, clayey	0 2		
	Coal	0 6		
	Band, clayey	0 3		
	Coal	2 0		
			3	2
17. Shale, dark brown			4	7
18. Grey post			1	0
19. Blue metal, with coal pipes			4	7
20. Hard, grey, scamy post, with blue metal partings			38	8
21. Blue metal			0	9
22. Grey metal			0	7
23. Blue metal			6	5
24. Grey metal			1	2
25. Grey post			2	5
26. Blue metal, with many coal pipes			0	2
27. Grey post			1	11
28. Blue metal, with coal pipes			0	2
29. Grey post, strong, with coal pipes			7	3
30. Grey metal parting, with coal			0	9
31. Grey post, strong			11	6
32. Black metal, mixed with coal			2	10
33. Grey metal			2	5
34. Blue metal			4	7
35. Strong ironstone girdle			0	3
36. Blue metal			8	10
37. Strong grey post girdle			0	8
38. Blue metal			7	4
39. Grey post girdle			0	6
40. Blue metal			1	7
41. Grey post girdle			1	10
42. Blue metal			0	10
43. Dark grey scamy post, very mild			6	0
44. Blue metal			6	10
45. White post, very hard and scamy			4	0
46. White post, mixed with grey metal			3	8
47. Blue metal, with *coal*			1	0
48. Post girdle			0	3
49. Post, with grey metal			4	10
50. Blue metal (hard)			10	5
51. Grey metal, with *coal*			1	0
52. White post			14	0
53. An exceedingly hard stone, apparently metamorphic, might be a pebble, from conglomerate (?) left off in this			0	3
			216	0

Across the north channel of the river a pit has been sunk at Tornago, and a good seam found at about 320 feet down, and is now, I perceive by the newspapers, being wrought.

At Hexham, on the south side of the river, is another extensive level plain, called Hexham Swamp, crossing this by a line of railway at present making, we come to a ridge again at the distance of 5½ miles, and to another sinking called Minimi. A seam, the section of which I give, is got here at a depth of 50 feet.

		Ft.	In.	Ft.	In.
	Roof, blue metal			10	0
Not worked	Coal	0	6		
	Band	0	0½		
	Coal	0	10		
	Band	0	0½		
				1	4½
	Coal, good	1	10		
	Metal band	0	0½		
	Coal, good	4	0		
	Bottom coal, not worked	0	10		
				6	8½
	Thill, grey post. *Dips S. 5°, not regular.*			8	1½

Coal has been worked to a very small extent at several different points between here and East Maitland, but, with the exception of two pits at Four-mile Creek, all are now closed *(Vide Plan No. 6)*. At Four-mile Creek, at thirty-four feet, the following seam is found:—

		Ft.	In.	Ft.	In.
	Roof mixed metal			1	7
Not worked	Coal, coarse	0	6		
	Band	0	5		
	Coal, coarse and splinty	2	2½		
	Band	0	1		
				3	2½
	Coal, good	3	7		
	Band, clayey	0	2		
	Bottom coal, good	1	2		
				4	11
	Dipping south-west 2°			8	1½

At Stoney Creek, two miles beyond West Maitland, a cannel coal has been found, of pretty fair quality, and is now wrought for landsale.

The Four-mile Creek coals are shipped at Morpeth, at the head of the navigation of the Hunter, about thirty-five miles by river and eighteen by road from Newcastle. Most of them, however, are used by the steamers plying between there, Newcastle, and Sydney.

Within three miles of Newcastle, to the south, a high ridge or range of high land runs inland from the coast, and joins the ranges which trend from Lake Macquarie. Here the Newcastle Coal and Copper (smelting) Company have their collieries. A thick seam, formed by one of the

undulations and the running together of two of the top seams, crops out on both sides of the ridge, and is worked by five day levels. One is driven quite through the hill, the full height of the seam, and forms a tunnel, through which the road to the smelting works passes.

SECTION OF THE BURWOOD SEAM.

ROOF POST.

		Ft.	In.	Ft.	In.
Not worked	Top coal	3	0		
	Fire-clay, good	2	2		
				5	2
	Coal, good	2	1½		
	Fire-clay band	0	2½*		
	Coal, good	0	4½		
	Danty band	0	2½*		
	Coal, good	2	4		
				5	3
	Thill, sagar clay, good. Dip west 4°.			10	5

The same company formerly worked the "Dirty seam" on the coast for smelting purposes, and now work it a little to convert into coke. Between 400 and 500 tons are brought to day at these drifts per day, and drawn in two-ton waggons, down a railway, by horses, to the shoots at Newcastle. Locomotives have lately been ordered from England for this railway, which is being relaid with heavier rails.

The Australian Agricultural Company have just received two locomotives to run on their lines up to the *D*, *E*, and *F* Pits.

At Lake Macquarie, coal was formerly worked at the Ebenezer colliery, but the coal, although it burns well, yet has such a dull appearance, that the pit has long been closed.

SECTION OF SEAM.

	Ft.	In.
Top coal, bright	0	6
Band clay	0	0½
Black slate	0	4
Cannel, coarse	2	6
	3	4½

This seam is just above high water mark, and has the conglomerate immediately superimposed on it.

The entrance to Lake Macquarie is very shallow, being obstructed by a sand-bar, which has only about four feet of water on it at high water.

This lake is most probably the synclinical curve of an undulation, not silted up.

* These bands are not regular, thinning out in some places, and in others disappearing altogether.

I give below the analysis of the coals I have mentioned :—

	Coke.	Gas.	Ash.	Sulphur
The Burwood coal sp. g. 1·293 ..	67·60 ..	32·40 ..	4·16 ..	7·03
" Ebenezer, Lake Macquarie coal	69·10 ..	30·90 ..	5.64 ..	7·18
" Four Mile Creek coal.....	71·90 ..	28·10 ..	4·00 ..	7·2[illegible]
" Minimal coal.....	75·50 ..	24·50 ..	6·60 ..	7·2[illegible]
" Australian Agricultural Company's *D. & E.* pit coal ..	64·68 ..	36·22 ..	6·52 ..	7·[illegible]

To show the increase of the coal trade of New South Wales, I g[illegible] the vend of the following years :—

	Tons.
In 1825, Government convicts working	2,789
" 1832, Australian Agricultural Company's monopoly	7,143
" 1833, Ditto ditto	6,812
" 1834, Ditto ditto	8,491
" 1855,.....	137,076

At the present time the vend is about and not exceeding 5,000 tons [illegible] week, and the price at the shoot is fifteen shillings per ton at present.

The trade is, at present, with a very small exception, a coasting [illegible] and to the neighbouring colonies of Victoria, South Australia, Tasma[illegible] and New Zealand. A very fine foreign trade, particularly with Califor[illegible] might by this time have been obtained, but, during the excitement [illegible] by the gold, when the harbours were filled with foreign vessels wai[illegible] for coal, the trade was anything but fostered.

IRONSTONE.

There is an abundance of ironstone, but it is much disseminated throughout the different strata, in the form of nodules or beds, extending for a very short distance. The following is the section of a bed of no great extent, about four miles down the coast south of Newcastle, and lying immediately under a seam of coal of 14 feet 9 inches in thickness, and which is formed of two seams having here run together—

	Ft.	In.
Ironstone beds	5	6
Soft clayey metal	1	0
Ironstone, apparently rich	2	6
Soft grey metal	2	0
Coal	0	9
Ironstone, a species of black band	0	6
Ironstone, light coloured	0	6
	12	9

Fireclay is also very abundant; it is generally rather aluminous, but by mixing the different qualities together with sand, I have obtained very excellent fire-bricks.

† Although the New South Wales coal contains, I think, a larger proportion of sulphur than the coal here, yet the proportion stated in the above analysis is probably too great. The analysis was made in Sydney, and a mistake may have been made. I find the following analysis in the Sydney (New South Wales) Parliamentary Blue Book :— 82·39 carbon. 5·32 hydrogen. 1·23 nitrogen. 1·70 sulphur. 8·32 oxygen. 2·04 ash. The per centage of sulphur here is slightly greater than in the most of our coals here.

CR
Brisbane Roads
Yale's Discharge
MBULL
CR
CR
Luggage Pt
ISLES
Low Island
CR
FISHERMAN
St HELENS
entrance
GREEN ISLAND
ALPA
CAPALABA

LOIRI
GA

EXPLANATION OF THE MAP OF FRANCE.

The basins or fields from which the coal is extracted are indicated by their names and as nearly as possible by their recognized shape. The quantities produced are expressed by *squares*, varying in size according to the extent of the respective fields; the square of one inch representing a production in round numbers of 700,000 tons. The number of tons is placed at the bottom of each square.

CONSUMPTION AND DISTRIBUTION.

The great quantity of coal consumed in each department is expressed by a *circle* drawn round the principal town, and, like the squares, varying in size according to the quantity taken into consumption. The circle enclosing a square inch represents a similar quantity to that expressed by the squares—namely, 700,000 tons,—and the precise number of tons sent from foreign countries, and from different native fields to each department, is placed round the circle.

The coals supplied by the various foreign countries are distinguished in the following manner:—

NATIVE COALS.—Lines of circulation *Black;* horizontal lines in the circles; colour, *Yellow.*

BELGIAN COALS.—Lines of circulation, indicated by *oblique strokes*; lines in the circles vertical; colour of lines and circles, *Green.*

ENGLISH COALS.—Lines of circulation and circles stippled; colour, *Red.*

PRUSSIAN COALS.—Lines and circles blank; colour, *Violet.*

The means of tracing the French coals to their source is afforded by the addition of the figures surrounding the circles, if accompanied by initial letters corresponding to the list of fields or basins in the General Explanation.

The *lines* of circulation are alternately coloured in cases where coal of different countries passes over the same route. Those of the routes who do not bear any written designation, are imperial or county roads and boundaries. The lines drawn beyond the coast indicate the Maritime routes.

ERRATA.

Page 68, 18th line from top, *for* 2,126 tons *read* 3,000.

„ 105, at Lot and Garonne, second column, *for* 23,600 *read* 2,360.

GENERAL EXPLANATION.

Varieties.	Basins whence derived.	Departments in which the Basins are situated.	
Bituminous Coal	Ahun	Creuze	A
Lignite	Aix	Mouths of the Rhône, Var	B
Bituminous	Alais	Gard, Ardèche	C
Do.	Argental	Corrèze	D
Do.	Aubenas	Ardèche	E
Do.	Aubin	Aveyron	F
Lignite	Bagnols	Gard	G
Do.	Banc-rouge	Ardèche	H
Bituminous	Bert	Allier	I
Lignite	Bourg	Aisne	J
Bituminous	Bourg-Lastic	Puy-de-Dôme	K
Lignite	Bouxwiller	Lower Rhine	L
Bituminous	Brassac	Puy-de-Dôme, Upper Loire	M
Anthracite	Briançon	Upper Alps	N
Bituminous	Buxière-la-Grue	Allier	O
Lignite	La Cadière	Var	P
Bituminous	Carmeaux	Tarn	Q
Lignite	La Caunette	Hèrault, Aude	R
Bituminous	Champagnac	Cantal	S
Do.	Chapelle-upon-Dein	Saône and Loire	T
Do.	Commentry	Allier	U
Do.	Creuzo and Blanzy	Saône and Loire	V
Do.	Decize	Nièvre	X
Do.	Denis Le Grand	Doubs	Y
Anthracite	Le Drac	Isère	Z
Lignite	Douvres	Ain	a
Bituminous	Durban and Segure	Aude	b
Do.	Epinac	Saône and Loire	c
Lignite	Estavar	Eastern Pyrénées	d
Bituminous	Ferques	Straits of Calais	e
Do.	Fins and Noyan	Allier	f
Anthracite	Fréjus	Var	g
Bituminous	Gémonval	Upper Saône	h
Do.	Gouhenans	Upper Saône	i
Do.	Hardinghen	Straits of Calais	j
Do.	Langeac	Upper Loire	k
Do.	Littry	Manche and Calvados	l
Lignite	Lobsann	Lower Rhine	m
Bituminous	Loire	Loire, Rhône, Isère	n
Do.	Lower Loire	Lower Loire, Maine and Loire	o
Anthracite	Le Maine	Mayenne, Sarthe	p
Lignite	Manosque	Lower Alps	q
Bituminous	Meimac	Corrèze	r
Lignite	Méthamis	Vaucluse	s
Do.	Milhau	Aveyron	t
Bituminous	Norroy	Vosges	u
Lignite	Orange	Vaucluse	v
Anthracite	Oysans	Isère	x
Bituminous	Roanne	Loire	y
Do.	Rodez	Aveyron	z
Do.	Ronchamp	Upper Saône	*a*
Do.	Ronjan	Hérault	*b*
Do.	St. Etoy	Puy-de-Dôme	*c*
Do.	St. Foy-l'Argentière	Rhône	*d*
Do.	St. Gervais	Hérault	*e*
Do.	St. Pierre-Lacour	Mayenne	*f*
Do.	Terrasson	Corrèze, Dordogne	*g*
Lignite	La Tour-du-Pin	Isère	*h*
Bituminous	Valenciennes	Nord	*i*
Do.	Vouvant	Vendée	*j*

NOTES

ON THE

PRODUCTION AND CONSUMPTION OF COAL IN FRANCE.

By Mr. T. Y. HALL.

INTRODUCTION.

In continuation of the series of statistical notes on the origin, progress, and present state of the coal trade of various countries,—partially commenced in my papers on "The Great Northern Coal-field" and "The Coal Measures of Styria," and more fully developed in the paper on America which I had the honour of reading to the members of the Institute,—I purpose taking into consideration the resources, production, and trade of France in this staple article of commerce, as the coal consuming country next highest in rank to Great Britain. I shall continue the comparison between the individual production and consumption of each separate district and county and those of our own and other countries, inasmuch as it is of the highest importance that the relative mineral wealth and capability of production of great and competing nations should be clearly and accurately defined and understood.

I have taken care throughout these papers—as well in those which precede as in the present one—that all calculations should be based upon official returns, wherever they were procurable; and in cases where I could not obtain the statistics from the coalowners' returns themselves, or documents issued under the authority of the Government, I have furnished liberal estimates, founded upon specified, and, I believe, accurate data.

Our information relative to the state of the coal trade in France prior to the year 1832 is, in many respects, unsatisfactory. We know little

or nothing of the extent of territory explored, the number of mines in operation, or the amount of industry at that period devoted to this now most important branch of commerce. True, we have certain figures representing the total yield from as early a period as the year 1787, just as we have now, in our own country, statistics of agricultural produce; and yet we know that the latter are so notoriously imperfect as to have excited the attention of the Legislature, by whom, during a recent session, the subject of a compulsory enactment which should oblige every farmer, under penalty, to furnish accurate returns of the production of each acre under his cultivation, has been freely canvassed and advocated.

It was in the year above-mentioned—1832—that the French Government instituted the system of commercial inspection which has since enabled them to estimate their mineral and agricultural produce, and to ascertain their commercial position with so much certainty and correctness. Every quintal of coal raised, and of iron, &c., manufactured, together with the exact number of bushels of grain grown yearly throughout the empire, is now noted down and preserved in the statistical records of the State, and the Government is thus enabled to fix with great accuracy the royalty rents, &c., upon minerals (which appear in every instance to be under the control of Government), and the duties which they levy upon grain and other produce. At certain periods these returns are assorted and condensed, and the results are published in a series of blue books, accessible to all.

Up to the revolutionary period of 1848, the Administration of Public Works had published these blue books annually; but, in that year, the power to defray the expenses of their publication was swept away, and the accounts, in consequence, ceased to appear. A new enactment, in 1850, ordained their triennial publication, and in this manner they have since been issued. Whether or not such a system would work in England—where, at present, commercial statistics consist mainly of estimates prepared by individual producers—is pretty much a matter of opinion, to be discussed elsewhere. That the system has been successful in France, Prussia, Austria, and in Belgium, where it has been in operation for a lengthened period, is beyond all question.

With this brief introduction, necessary to explain the objects of the paper, and to show the kind of authority upon which I found my calculations, I shall at once proceed to the subject matter.

CHAPTER I.

HISTORY AND PROGRESS OF THE FRENCH PRODUCTION OF COAL.

The first account we have of coal being used in France to any noticeable extent bears date 1700. According to M. Vivien, Secretary of State for the Department of Public Works during the reign of Louis Philippe, there is reason to suppose that coal was employed in France before the fourteenth century, and he affirms it as certain that, in the year 1331, coal was extracted from the mines of Roche-la-Molière, in the Loire basin. Two centuries after—namely, in 1520—coal began to be imported from England into Paris, and a good deal of excitement as to its effect upon the atmosphere, and the health of the inhabitants, was created. The Faculty of Medicine were consulted, and they reported that, with proper precautions to avoid the inconvenience arising from the smoke, coal would not act in any way prejudicially to the public health. In the year 1548, one Jean François de la Roque, Sieur or Master of Roberval, obtained from the French King Henry II. the exclusive privilege of working the coal mines of the kingdom; but, in 1553, on the occasion of a destructive epidemic, the smiths were forbidden, under pain of imprisonment and fine, to consume coal in their shops, when, it may be supposed, the Master of Roberval's license would be of little profit. Henry IV., in 1601, specially exempted coal from the tithe due to the sovereign in virtue of his royalty, and the privilege was continued by his successor; but Louis le Grand, in 1667, imposed upon all coal imported a tax of 97 centimes per 100 kilogrammes (about 8s. per ton), and this high duty he raised to 1f. 21c. (about 10s. per ton), in 1692. This monarch seems to have been determined to shut out foreign coals as much as possible, and by that means to develope the coal produce of his own kingdom, for we find him, six years after the last-named date, issuing an edict which authorised landowners to explore the coal upon their estates without seeking permission of the sovereign. Thus encouraged, several landed proprietors turned their attention to mining operations, and, by the commencement of the eighteenth century, coal was very actively worked in the basins of the Loire and Brassac, while its extraction had begun and was rapidly progressing in the basins of Alais, Roujan, Saint Gervais, Aix, Caunette, Ségure, Aubin, Decize, Ahun, and Lower Loire. The Saint George's mines were opened in 1720, and, a few years later, those of Litz, in Calvados, Valenciennes,

Hardinghen, and Creusot and Blansy. In 1744, an edict of Louis XV. annulled the legislation of 1698, and rendered it necessary to obtain the royal permission to work coal; while another edict, issued about twenty years after, reduced to 1f. 10c., and in a few months to 83c. per 100 kilogrammes (equal to 6s. 11d. per ton), the duty upon all coals brought oversea. By this time the Carmeaux, Littry, and Ronchamp fields had been discovered, and the home trade had become important; so much so, indeed, that, in 1787, the native extraction amounted to 215,000 tons, while the foreign importation was only 217,378 tons. The next year the home yield was 10,000, and the year following 15,000 tons more—a very satisfactory increase under the circumstances. At the commencement of the present century, the home production was 800,000 tons.

French Importation of Foreign Coal.

The foreign importation appears to have seriously declined at the beginning of the present century. The returns in 1815 present an extraordinary decrease. They are even far below those of the year 1788, for in that year the figures were 240,000 tons, whereas, in 1815, the total supply was only 165,345 tons. At first sight it might be imagined that the falling-off was attributable to, and the legitimate consequence of, an increasing development of native produce; but the supplies in subsequent years destroy the supposition. We must, therefore, refer to history, which informs us that, during the war with France, Buonaparte, determined, if possible, to extinguish our commerce with that country, laid an embargo on all English goods entering the empire, and the stringent measures he enacted to effect this object were successful for a time in excluding English coal from the French market. Had he adopted the more reasonable course, and reduced the duties instead of raising them, France would by this time, in all probability, have taken ten times the present quantity of English coals, or more than Belgium has ever sent, the probable effect of which would have been to raise France to a high position amongst manufacturing nations. By and bye we shall see how differently the more liberal policy laid down by the present Emperor is acting.

Native Yield and Foreign Importation in the Year 1820.

From this date—1815—there was a steady increase in the quantity of native coal extracted, subject, of course, to those fluctuations in the

market which a state of warfare with nearly all Europe might be supposed to induce, till, in the year 1820, four years after the war, we find the total yield estimated at 1,093,657 tons, an annual average increase of 71,341 tons. The foreign importation, too, advanced. It amounted to 280,920 tons, or an increase per year of nearly 20,000 tons. The total supply was furnished by the undermentioned countries, viz. :—

	Tons.
Belgium	227,212
Prussia and Bavaria	27,814
Great Britain	25,119
Various countries	775
Total	280,920

The British production in 1820 I estimate at twenty-two million tons, of which about one-fourth was extracted in Northumberland and Durham. This, from the very imperfect data obtainable, appears to me to be a tolerably accurate calculation. Of this latter extraction probably a third (or one-eighth of the whole) was *shipped* from these northern districts.

Produce and Importation in the Year 1825.

By the year 1825 an augmentation in the native extraction, to the extent of 1,491,381 tons, had taken place—an average increase of 80,000 tons per year. The increase of foreign importation had also been proportionally large during the quinquennial period, it having advanced to 508,618 tons (including 1,680 tons of coke)—about 100,000 tons per year. The total is made up as follows :—

	Tons.
Belgium	439,248
Prussia, &c.	42,393
England	26,684
Other countries	293
Total	508,618

The English production at that period I estimate at 26,000,000 tons, 24,000,000 tons more than the whole native and foreign supply of France added together; while America, just then coming into notice, was furnishing for local consumption a supply of only 30,000 tons, about half the quantity consumed, the remainder being imported from England.

Native and Foreign Supply in 1830, the Year of Revolution.

In 1830 the production had reached 1,862,665 tons, being only an increase of twenty-five per cent. over the year 1825, while the increase of the latter year over 1820 was fifty per cent. It should, however, be stated that the returns for 1830 do not fairly represent the case. That was the year of revolution, and consequent disorganization, when the machinery of commerce was dislocated, and its operations, as it were, suspended—when civil disorder reigned unchecked, and the routine of everyday life, the ordinary business of buying and selling, were conducted with fear and reluctance. The foreign importations in this year was 637,291 tons. The supplies were from the under-mentioned countries :—

	Tons.
Belgium	510,806
Prussia, &c.	75,344
England	51,128
Other countries	13
Total (including about 5,000 tons of coke)	637,291

Introduction of the System of Mine Inspection and Reduction of Duties on Foreign Coal.

Passing on to the expiration of the succeeding five years, and comparing the total supply of the year 1835 with that of 1830, we find a comparatively large increase of all kinds. The nation had by this time become tranquil; commerce and industry flourished again. Capital, which everybody hesitates to invest during times of internal commotion and disorder, was again gradually put into active circulation in developing the national resources and trade. Science had brought to its aid improved mechanical contrivance and skill, and a time of general prosperity had begun to dawn. The French Legislature, three years before the date to which these statements extend, had instituted the system of mine inspection by competent mining engineers, and the result has been most satisfactory. As has been well remarked elsewhere, "the productiveness of mining industry in France has increased, in a greatly accelerated ratio, since that time, as compared with previous periods, which circumstance is, in part at least, attributable to the suggestions made to the proprietors of mines by the engineers, a highly educated and intelligent body of men, to whom the task of inspection is confided." Another wise, and, as the sequel has shown, profitable action on the part of the French Legislature during this quinquennial period, was the reduction, in the year 1834, of the import duties on the seaborne coal

(mostly English) to 2s. 6d., 5s., and 8s. 4d. per ton, according to the respective districts into which it was brought; while the duties on foreign coal brought by canal or overland—from Belgium, for instance—was reduced from 2s. 6d. to 10d. and 1s. 3d., according to the above rule. The beneficial results of these measures—imitating the course of action pursued in this country in 1831—are seen in the large increase of the foreign supply ever since, though the differential duties in favour of Belgium still operate unfavourably on the English trader, and allow Belgium to take the lead of England in supplying coals to France.

NATIVE EXTRACTION AND FOREIGN SUPPLY IN THE YEAR 1835.

The production of French coal in the year 1835 was not less than about 2,506,416 tons, an excess over that of 1830 of about 650,000 tons, or 33 per cent. Perhaps, as the year 1830 was peculiar, it would only be fair to compute the increase on 1825, when it will be seen that the average annual increase is about 100,000 tons. The foreign import in this year amounts to above three quarters of a million tons, (including 9,249 tons of coke and 16,984 tons of coal, which, being entered simply as fuel for government vessels, is excused duty, in accordance with the provisions of a law which was passed by the French Legislature about this time), of which there came from

	Tons.
Belgium	615,157
England	98,159
Prussia, Bavaria, &c.	87,783
Other countries	21
Total	803,120

The aggregate supply of all kinds in 1835 is thus seen to have been, in round numbers, 3,309,536 tons, about 662,000 tons each year.

The number of mines in operation in the year 1835 is stated to have been 223, namely, of bituminous coal, 157; of lignite, 42; of anthracite, 24. The amount of labour employed in these 223 mines during this year is estimated at 19,484 hands (which includes both below and above ground labour), averaging about eighty-seven men to each mine. Assuming this statement to be correct, we have an average production from each mine of 112,400 tons—nearly 126 tons to each workman per year.

The English yield in 1835 may be estimated at 30,000,000 tons, scarcely half the present extraction; that of Belgium was 2,647,379 tons, raised from 307 mines (8,623 tons per mine); Prussia, 2,000,000

tons, raised from 330 mines by 16,000 workmen, an average of 6,060 tons per mine, and 127 tons per man; and America, 450,000 tons.

The following is the official table of the consumption of fuel in France during the year to which these statements refer :—

CONSUMPTION OF FUEL IN FRANCE IN 1835.

	Tons.*	Value.*	Value Per Ton.
Charcoal	600,000	....£1,488,360	.... £2 9 7¼
Mineral coal...	206,800	 167,800	.... 0 16 2
Coke	59,000	 63,840	.... 1 1 7½
	Stère†		
Wood	8,100	 1,560	
Turf	6,500	 400	
Total value		£1,718,960	

HOME SUPPLY DURING THE YEAR 1836.

During the next year, 1836, 2,841,946 tons were raised by 21,913 workmen, 130 tons to each individual employed. The average extraction per mine was about 10,000 tons, and the mean value per ton, as set forth in the official documents, 11s. 3½d. Thus the average value of the quantity extracted by each operative throughout that year would be £73 8s. These figures show a steady increase.

The value of the principal mineral productions extracted in France during the year 1836 was £6,169,138; that of all sorts of coal, £1,064,082, about one-sixth of the whole of the mineral extraction. The increase in value, as well of coal as of the principal varieties of other mineral produce, seems to have been in pretty regular proportion to the increase in the supply, subject to the almost imperceptible cheapening of the article by the continued introduction of mechanical improvements in subterranean operations, and by foreign competition. This rule, of course, applies, without exception, to every mineral producing country in the world. During the last twenty-five years the cost of production, and, in consequence, the price to the consumer, in many parts of England, has been reduced by the same means full 33 per cent., the increase of production going on at the same ratio.

* Throughout this paper I have reduced the figures from French quintals into French tons, by cutting off the last figure from the number of quintals; and the value from francs to pounds, by cutting off the last two figures and multiplying the remainder by four. The French ton is a little less than the English ton, but the calculations are sufficiently accurate for our purpose.

† A Stère is equal to 1·31 cubic yards, or 35 cubic feet, 547 cubic inches = nearly 1¼ cubic yards.

Comparative Productiveness of the French, Belgian, Prussian, and American Coal Fields in 1838.

In the course of the year 1838, 3,113,252 tons of coal were raised in France by 23,751 workmen, employed in 221 pits, namely, 157 working and 64 sinking pits. In Belgium, in the same year, 480 working and 172 sinking pits were in operation, employing 37,170 miners, producing nearly 3,300,000 tons. The production of England, at that time, was estimated at 36,000,000 tons:—that of Prussia at 2,308,368 tons, extracted from 628 pits by 17,884 workmen:—and, that of America—where labour is very expensive, costing nearly double the price paid in England, and about three times more per individual than in other foreign countries—at about three-quarters of a million tons.

Native and Foreign Supplies in 1840.

But to resume our quinquennial comparisons of French production. In the five years 1835–40, a large and satisfactory increase, though one apparently less in proportion than that of the previous five years, is shown. The total extraction in the year 1840 amounted to about 3,000,000 tons, or 800,000 tons over the quantity extracted in 1835. The foreign supplies in 1840 are classified as below:—

	Tons.
From Belgium	748,600
„ Great Britain	380,774
„ Prussia, &c.	160,779
„ Various	507
Total (including about 11,000 tons of coke and 8,000 or 9,000 tons of coal entered for government vessels)	1,290,660

The period embraced by the latter part of the quinquennial term 1835–40, and the first part of the similar term 1840–45, would seem to have been very prosperous, not only for the important branch of commerce at present under our consideration, but also for almost every other kind of trade. Midway between two great revolutions, those of 1830 and 1848, the French nation appears to have rested on its oars, as it were, and to have given the fullest scope to the development of its large resources. Ample time had elapsed since the unfortunate and calamitous disaster of 1830 for the kingdom to recover its wonted composure, and the Legislature seems to have set itself diligently to work to promote, by every means in its power, the extension of commerce, home and foreign; the growth of the national industry, and the prosecution or pursuits, from the successful following out of which they hoped to derive advantages commensurate with those which had attended a similar course of action in neighbouring countries.

The number of French mines in operation in the year 1840 is said to have been 250. Supposing that number to be accurate, we have an average production per mine of 12,000 tons. The number of labourers employed in mining operations in that year was 27,830, so that the average number of tons raised by each workman was 108.

Two departments, those of Moselle and Lot, which had each furnished a small quantity of coal in the year 1835, had ceased to do so in 1840. Moselle had, at one time, yielded no inconsiderable quantity, and, indeed, in the first-named year her production stood at 3,000 tons; but Lot had dwindled down to 60 tons, and was the lowest of all the departments. It appears, however, that the Emperor has recently ordered borings to be made in Moselle, which have been attended with favourable results, and that operations on an extended scale are contemplated. Both the districts seem to have been deserted for new and more profitable localities, for we find that, at the same time they ceased to figure in the market, thirteen other departments were added to the coal-yielding list.

It will now be interesting to ascertain what has been the ratio of progress in the native production and importation of foreign coal into France during the last twenty years, over which our comparisons extend. We have seen that, in the year 1820, the quantity of native coal extracted was only 1,093,657 tons, and that the foreign supplies amounted to 280,919 tons. We now (1840) find upwards of 3,000,000 tons placed to the credit of the home production, and the foreign trade arrived at 1,290,660 tons. To show the relative increase of one term of years over another is the object of the following table:—

PROGRESS OF THE FRENCH COAL TRADE DURING TWENTY YEARS.

Years.	Quantities raised.	Increase* since 1820.	Increase since 1825.	Increase since 1830.	Increase since 1835.
	Tons.	Tons.	Tons:	Tons.	Tons.
1820	1,093,000	....	....	....	....
1825	1,500,000	407,000	....	....	....
1830	1,862,000	769,000	362,000	....	....
1835	2,500,000	1,407,000	1,000,000	638,000	....
1840	3,000,000	1,907,000	1,500,000	1,138,000	1,000,000

It is thus shown that the aggregate increase in the twenty years was

* These calculations are made in round numbers.

nearly 2,000,000 tons, about 100,000 tons per year. The per centage of increase over each respective period is as follows:—

Years.		Years.	Increase per Cent.
1825	over	1820	37½
1830	„	1825	24½
1835	„	1830	34
1840	„	1835	20

Computing the increase over the whole twenty years, we have a difference between 1820 and 1840 of 175 per cent., or, estimating it from the somewhat early period of 1814, when the home trade was in its infancy, we obtain an increase of nearly 500 per cent., nearly 90,000 tons per year.

The progress of the French foreign trade in coal during the same period is shown in the subjoined tabular statement:—

IMPORTS OF FOREIGN COAL INTO FRANCE DURING TWENTY YEARS.

Years.	Quantities imported.	Increase since 1820.	Increase since 1825.	Increase since 1830.	Increase since 1835.
1820	280,920	....	....	....	....
1825	508,600	227,680	....	....	....
1830	637,291	356,371	128,691	....	....
1835	763,000	512,081	284,400	155,709	....
1840	1,290,660	1,009,740	782,660	653,361	497,652

These figures exhibit an aggregate increase over the whole period of nearly 1,020,000 tons, or 455 per cent., an average yearly augmentation of upwards of 50,000 tons. The per centage of increase of each respective period over its predecessor may be stated thus:—

Years.		Years.	Increase per Cent.
1825	over	1820	80
1830	„	1825	25
1835	„	1830	25
1840	„	1835	64

It is thus shown that, while the native production has increased during the four periods in the ratio of 3 to 1, the importation of foreign coals has increased in the ratio of nearly 5 to 1 over the same number of years. This is a significant fact, and from it we may draw conclusions highly encouraging to Great Britain, the following having been the import of coals from that country in the respective septennial periods:—

	Tons.		Tons.
1825	26,684	1835	98,159
1830	51,128	1840	380,774

Home and Foreign Supplies during the Year 1841.

Very accurate and elaborate statistics are given of the home production and foreign supply of coals in France during the next year, 1841, which I cannot forbear making use of. The total extraction of native coal in this year amounted to 3,410,200 tons, which, distributed amongst 256 mines—the number in operation—gives an average yield from each mine of 13,321 tons. This, it will be observed, is a clear increase of 3,500 tons per mine, as compared with the figures for 1836. The number of workmen employed in raising coal in 1841 was 29,320—22,595 in the pits and 6,725 aboveground; so that, on an average, each man produced 116 tons, exactly the same quantity as was raised per man five years previously, or when the hands were 7,000 less in number. It is, therefore, obvious that no advancement had been made on each man's yearly production in working the mineral. But, if no improvements in manual labour had taken place, it is evident that the French miners had profited by the example set them by England* in 1832–3, inasmuch as we find the cost of production in this year (1841) stated to have been 7s. 9¼d. per ton, a reduction on the cost per ton in 1836 of 3s. 6¼d., and a striking proof that improvements of a most substantial and effective nature were required, and were being carried out. The total value of all kinds of minerals raised in France in that year was £7,134,243; that of coal being £1,326,361.

The foreign coal (including coke, &c.) entering France in 1841 was supplied in the following proportions:—

	Tons.
Belgium	992,226
Great Britain	429,950
Prussia, Bavaria, &c.	196,502
Various	482
Total	1,619,160

Home and Foreign Supplies in 1845.

Our next quinquennial period terminates with the year 1845, and the

* I allude here to the improvements introduced by me into the Great Northern coal-field about this period. They consisted of the adoption of tubs, with carriages attached, in lieu of corves, and angle iron tram plates, for drawing coals from the extremities of the workings to the bottom of the shaft, and slides or guide rods for conducting them thence to the surface. These led to other improvements, such as a uniformity in the width of railways underground, by means of edge rails of a much lighter construction, and the skilful application of powerful steam machinery, especially to underground operations. The average saving per ton in England by the general adoption of these improvements, if taken at only 1s. 3d. per ton, 2s. 0¾d. less than the sum given above, amounts to upwards of four million pounds per year upon the total produce, or upwards of one million sterling upon the present annual yield of the Northumberland and Durham coal-fields.

returns relating to it are of the most gratifying character. The total extraction was 4,202,091 tons. Thus we have a clear average yearly increase of 200,000 tons, or 1,000,000 tons in the aggregate.

Of foreign supplies the number was more than proportionally augmented. Thus we have a total importation of 2,207,194 tons (including 132,756 tons of coke and 62,156 tons of coal entered for ships belonging to the state), furnished as follows:—

	Tons.
From Belgium	1,396,167
„ Great Britain	565,748
„ Prussia, &c.	240,695
„ Various	4,584
Total	2,207,194

Showing that while the home yield has increased 25 per cent., the importation has been augmented at the rate of 50 per cent. In fact, it had doubled itself within ten years.

The Effects of the Revolution of 1848.

We now come to a period of so many changes in the political aspect of France, and of so much interruption to industry and commerce, that it will be necessary to depart from the classification hitherto pursued, and, in lieu thereof, to adopt a somewhat irregular system of computation. It will have been observed, by what I have already stated, that the coal trade suffered severely by the civil contentions of 1830; how much more severely, then, must it have felt the more protracted disorganization of 1848 and subsequent years? The revolution of 1830 was adjusted within no very lengthened period, and necessitated no very material change of government; that of 1848, on the contrary, was a fierce, desperate, and prolonged struggle.

This cursory remark, unbiassed by any political notions—all of which are, very properly, excluded from papers read before this Institute—will account for the extraordinary depression which, as subsequent figures will reveal, the French coal trade sustained during these exceptional years to which we refer.

The production had gone on with the usual vigour, increasing in pretty nearly the same ratio as would have been estimated from reading the statistical statements preceding, until the end of 1847, when it had arrived at nearly 5,000,000 tons. This amount, computed on the annual increase of the term of five years ending 1845, shows a large excess of increase per year. Then came the revolution, and the native

yield sunk at once to 4,000,433 tons, or less than it was in 1844. The number of workmen engaged in the various operations of the trade in 1847 was 34,791, producing, on an average, 143 tons, or 23 per cent. more per man than was extracted in 1841 and 1836; but, in 1848, the number of employés had fallen to 31,966, and the average number of tons extracted by each man to 123, equal only to the individual production of 1842. The yield in one department alone, that of Nord, fell off to the extent of 500,000 tons, while the department of Loire sustained a decrease in its production of 400,000 tons.

The better to show the extent of depression sustained by the different departments during the revolutionary year, I subjoin the following table. It contains statistics relating to five of the principal departments, and affords reliable data for calculating the diminution of the produce and labour in the remainder.

Departments.	1847.				1848.					
	Workmen employed.			Production.	Workmen employed.			Production.	Decrease of Hands.	Decrease of Production.
	Underground.	Aboveground.	Total.	Tons.	Underground.	Aboveground.	Total.	Tons.		Tons.
Loire	5,415	1,802	7,217	1,722,583	5,161	1,792	6,953	1,326,687	264	395,896
Nord	8,189	1,925	10,124	1,245,651	7,991	1,582	9,573	927,311	551	318,340
Saône and Loire.	2,080	788	2,868	525,874	1,759	868	2,627	381,595	241	147,279
Gard	1,872	396	2,268	467,332	1,291	231	1,522	358,307	746	109,032
Allier	1,115	689	1,804	228,683	1,085	667	1,752	191,721	52	36,962

The depression estimated from the returns of the five principal coal-fields is as follows:—

Fields.	Production in 1847.	Production in 1848.	Decrease.
	Tons.	Tons.	Tons.
Loire	1,722,581	1,326,687	395,896
Valenciennes (Nord)	1,245,651	927,311	318,340
Alais	457,579	353,160	104,419
Creusot and Blanzy	387,396	284,640	102,756
Aubin	211,744	126,640	85,104

The annexed table shows the decrease, according to the different varieties of coal :—

Nature of the Coal.	Production in 1847.	Production in 1848.	Decrease.
	Tons.	Tons.	Tons.
Free burning smithy coal	2,623,704	1,871,800	751,904
Uninflammable ditto	885,259	675,559	209,700
Smithy coal	480,716	448,297	32,419
Hard coal	320,473	296,933	23,540
Anthracite	659,029	542,239	116,790
Lignite, stipite, &c.	174,930	165,601	9,329
Total	5,144,411	4,000,429	1,143,592

The returns of the consumption for 1848 present a falling-off of upwards of 1,800,000 tons, while the foreign importation sustained a decline of 405,000 tons. A tabular statement of the foreign supplies during both years gives the following result :—

Country whence supplied.	Quantity, 1847.	Quantity, 1848.	Decrease.
	Tons.	Tons.	Tons.
Belgium	1,686,990	1,399,380	287,610
Great Britain	586,520	514,920	71,600
Rhenish Provinces, Prussia, &c.	272,330	227,090	45,240
Other countries	2,880	2,380	500
Total	2,548,720	2,142,770	404,950

The number of mines in operation exhibited only a very slight decline, it having been 258 in 1847, and in 1848 it was 256. Much less however, was yielded by each mine; and the produce of individual labour was in the latter year very considerably below the average.

Revival of the Trade in 1849.

Thus much for the effects of the Revolution of 1848. We enter now upon an era of amelioration. In the year 1849 the home trade very slowly revived. Scarcely as yet, however, had commercial confidence been restored to owners and speculators, although affairs wore a decidedly

better aspect. The total quantity of coal extracted was 4,049,218 tons, 44,875 tons above the yield of the previous year, but 200,000 tons short of the produce of even 1845. The number of operatives engaged in the different coal-mining departments also received a slight augmentation, but was more than 2,000 less than in 1847, and their individual production per annum amounted to only 125 tons, about one-third of the average production per man per annum in the north of England. The foreign importation experienced the greatest per centage of increase of all the supplies which relate to this year. It rose from 2,143,770 tons to 2,393,950 tons. The supplies (including coke, &c., as before) were sent in the under-mentioned proportions from the customary countries of extraction :—

	Tons.
Belgium	1,591,320
England	572,140
Prussia, &c.	228,720
Other countries	1,770
Total	2,393,950

The number of working mines increased in this year to 270, and the extraction from each pit was, on an average, about 15,000 tons, a trifling rise on the last year's quotations.

Home Trade and Foreign Supply in 1850.

The year 1850 comes next for consideration, and here I might return to our quinquennial comparison, were it not obvious that, after the severe and unprecedented blow inflicted by the misfortunes of 1848, no just comparison could be instituted. The statistics of this year might, with a small augmentation, do duty for those of 1846—or, rather, so heavy was the weight of depression which had been thrown upon the trade two years before, that it had scarcely more than regained the position it occupied in the year 1846, the same number of years previous to the disaster. Nevertheless, the increase was not a disproportionate one for one year; indeed, no previous year's increase, even in the most prosperous times, had been greater. The average augmentation for the two years preceding 1847, one of the most prosperous seasons, was 430,000 tons a-year; while for the five years preceding 1845, also a good season, the annual average increase had been under 300,000 tons; but, in the year we now refer to, the increase amounted to about 400,000 tons. This was one of the calmest years of the republican period, and the tranquillity which characterised it was not unproductive of good results, for we find an increase going on in every department of the trade whose

progress it is the object of this paper to record. Three were added to the number of mines in operation, making 273, and 571 to the number of workmen; while the average extraction per mine was raised to 16,240 tons, and the quantity worked by each individual to 131 tons.

But by far the largest increase took place in the foreign supplies. I have shown that the home production had not, at this time, recovered the position which it held in 1847 by some 500,000 tons. The importations of foreign coal, however, exceeded those of 1847 by 250,000 tons, the total increase on the year being above 450,000 tons. The principal portion of this encouraging excess was contributed by Belgium and England, as will be seen by the subjoined comparisons:—

	1849. Tons.		1850. Tons.		Increase.
Belgium	1,591,320	....	1,953,190	....	361,870
Great Britain	572,140	....	602,410	....	30,270
Prussia, &c.	228,720	....	277,280	....	48,560
Various countries	1,770	....	380	....	1,390
Total	2,393,950		2,833,260		

Comparative Productiveness of the French, English, Belgian, and American Coal Fields in 1850.

The English yield by this year had reached considerably more than 50,000,000 tons, about a fourth of which quantity was contributed by the Northumberland and Durham fields. The Belgian extraction in 1850 was 5,800,000 tons, raised from 408 working pits by 47,949 operatives, giving an average extraction from each pit of 14,260 tons, and an individual production of 122 tons. The American yield in the same year was 3,555,747 tons, and the foreign importation 180,439 tons. Computed from the year 1838, when I made a similar comparison, the per centage of increase in the French production was 43½; in the English, 40; and in the Belgian 75; while in America the increase was nearly five-fold.

The Native Yield and Foreign Importation in the Year 1852.

Passing on to the year 1852, we find the French trade in a vigorous and flourishing condition. It had increased on the two years apparently but slightly, the augmentation being only some 470,000 tons; but during 1851 the home trade was not so satisfactory as might have been expected, which circumstance will account for the apparently small increase. The excess on the single year was 300,000 tons, the production of 1851 and 1852 being respectively 4,500,000 and 4,800,000 tons. The number of

mines in operation increased in this year to 286, the average quantity extracted from each being 16,433 tons—an increase on the two years of 193 tons. An addition of 711 miners was secured during the same period, but the individual extraction was only 107 tons.

The foreign importation, too, had experienced a very considerable augmentation. The figures which follow speak for themselves :—

	Tons.
Belgium	2,119,180
England	652,390
Prussia, &c.	324,260
Divers countries	1,330
Total	3,095,960

Comparative Productiveness of the French, English, Belgian, and American Fields in 1852.

The production of coal in Great Britain during the year 1852, I estimate at 55,000,000 tons; that of Belgium at 6,250,000 tons; while the total yield of America was 5,327,650 tons, and her importation (entirely from England), 183,015 tons. The per centage of productive increase in the four countries, computed from 1850, is, therefore—For France, 10½; England, 10; Belgium, 8; and America, 50.

Native and Foreign Supplies in 1853.

In the year 1853 we find the French extraction progressing in a very satisfactory manner. The production in that year was 5,928,877 tons, an increase of upwards of one million tons over that of its predecessor. I have not been able to obtain statistics of the number of mines in operation or of the workmen employed after the year 1852, but presume their increase was proportionate to that of the extra yield, as in former years.

The foreign importation for 1853 experienced considerable improvement also, the quantity sent into France by the different countries being 3,530,533 tons, an increase of 14 per cent. over 1852. This importation came, as near as I can ascertain, in the following proportions, from the undermentioned places, viz. :—

	Tons.
Belgium	2,456,959
England	703,704
Prussia, Bavaria, &c.	369,734
Other countries	136
Total	3,530,533

Home Yield and Foreign Importation in 1854.

The yield of French coal in the following year, 1854, exhibits an increase somewhat less than that of the previous year over 1852. The total quantity obtained was 6,827,007 tons, an increase of only 900,000 tons.

The supplies from foreign countries increased in this year in pretty nearly the same ratio as in the year preceding. The total importation reached 4,129,988 tons, an increase of nearly 17 per cent. on the year. The following table exhibits the relative contributions of the importing countries:—

	Tons.
Belgium	2,856,146
Great Britain	780,449
Prussia, &c.	492,989
Various countries	404
Total	4,129,988

Home and Foreign Supplies in 1855.

By the next year a perceptible improvement in the total quantity of coals extracted by the native producers may be noted, but again in a descending ratio of increase. The supply from all the home sources amounted to 7,453,048 tons, an increase of about 600,000 tons only. I regret my inability to exhibit, from the documents issued by the French Government, the precise reason for this gradual decline in the augmentation, but it is attributable in part, no doubt, to the continued increase in the imports of coal from England, Belgium, and Prussia.

The annexed table of the quantity of coal imported shows an increase in the foreign supply of about 700,000 tons, or 20 per cent. on the year, the total quantity exceeding the native production of 1852, only three years before:—

	Tons.
Belgium	3,327,333
England	953,990
Germany, Prussia, &c.	670,045
Other countries	846
Total	4,952,214

Comparative Productiveness of the French, English, Belgian American, Prussian, Spanish, Saxonian, and Australian Coal-fields, in the Years 1855 and 1856.

The production of coal in Great Britain in 1855 was 66 million tons, (about a million tons more than in 1854), of which 16½ million tons were furnished by the Great Northern Field.

The United States had nearly overtaken France; their production, exclusive of the small quantity locally consumed and not accounted for, being 7,278,572 tons, an increase of 627,939 tons on the year, and their importation (still entirely from England), 287,408 tons. In this year they exported 110,586 tons, which figures appear in the official statistics under the head of "Domestic Exportation." Canada is rich in coal mines, having thick beds of the mineral, which are now beginning to be worked more extensively than heretofore, and she is shipping part coal to the United States.

The production of Belgium in 1855 had attained to 8,409,330 tons, and was obtained from the following sources:—

Hainault	6,458,416 tons.
Liege	1,720,053 „
Namur	230,861 „
	8,409,330

The production respectively of France, Great Britain, and Belgium, in that year was as follows:—

	France.	Great Britain.	Belgium.
Per 1,000 inhabitants	173 tons.	2,126 tons.	1,804 tons.
Per 1,000 acres of surface	118 „	1,963 „	2,817 „

Saxony produced in this year nearly 1,000,000 tons of coal, all of which was taken into local consumption. The population of Saxony is nearly 2,000,000.

In Australia, where the working of coal is attended with great expense, owing to the high rents (about 2s. per ton), the great cost of labour, and of materials, which are imported from England, the shipments of coal were about 190,000 tons in 1855. Nearly the whole of this quantity was obtained from twelve pits, which are contained in a circuit of twenty-five miles. In my paper on the "Great Northern Coal-field," vol. II. of the "Transactions" of this Society, pages 231-2, I describe the coal districts of New South Wales, and estimate the quantity produced in 1840 at 27,000 tons. The mines were then under the baneful influence of a monopoly, which has since given way to competition. The average yearly increase in the production since that period is thus shown to have been 4,000 tons, only 15 per cent. per annum over the whole period. The selling price of Australian coal is about 15s. per ton.

The Australian yield of coal in 1856 was somewhat more than 250,000

tons. I cannot procure reliable returns of the precise quantity extracted, but the figures quoted indicate the shipments at the various ports, in addition to which a small quantity will have been taken into local consumption. A great deal of wood is consumed in this as well as in all other foreign countries; and this almost necessarily so, coal being exceedingly scarce, and, in some parts especially, difficult to obtain. I observe that Government have offered a large reward for the discovery of a coal-field in South Australia; and at a place called Kapunda, at a depth of forty feet, a sample of very good coal has been found.

With 1856 our information respecting the French coal trade is, of course, brought to an end. The total quantity extracted amounted to 7,740,317 tons, an increase on the yield of 1855 of only 297,269 tons.

The supplies of coal furnished to French consumers by importers in 1856 amounted to 5,069,999 tons, a slight increase only, as in the home production, upon the importation of 1855. The tabular statement is as follows:—

	Tons.
Belgium	3,119,630
England	1,165,878
Prussia, &c.	781,521
Other countries	2,970
Total	5,069,999

The exportation of coals and coke from France in 1856 was as follows, coal, 92,104 tons; coke, 7,392 tons.

These statements disclose a remarkable falling-off in the per centage of native production since the year 1853. In the last-named year the augmentation of native produce was at the rate of 20 per cent., and that of foreign only 14 per cent., upon the previous year; but, in 1854, the per centage of increase in the native yield fell to fifteen on the year, while that of foreign rose to seventeen on the same period. In the next year, the per centage of augmentation on the year in the home supply receded to nine; in the foreign it rose to twenty. Last year (1856), the per centage of increase upon the year in the native extraction descended as low as four; and in the foreign still lower, namely, to two and a half only. From the year 1852 to 1856, the aggregate increase in the quantity of French coal exceeds two million and three quarter tons, or 57½ per cent.; the foreign importations, estimated in the same manner, exhibit a gross increase of 63 per cent.

For the Belgian yield, I have not been able to procure statistics up to

so recent a period as 1856, but supposing it to have increased in a slightly accelerated ratio compared with the augmentation from 1852 to 1855, the total production will be about, but not more, than 8½ million tons. Indeed, I doubt whether I ought to give Belgium credit for any increase at all in this year, for, in the principal district, that of Hainault, Mons. J. Gonot, chief engineer and director of Belgian mines, reports a falling off in the extraction from 6,458,416 tons in 1855, to 6,219,132 tons in 1856, and unless Namur and Liege have shot a-head in a manner which I am hardly justified in assuming, the production will either have remained stationary or have increased insignificantly.

Prussia has increased her production five-fold within twenty-five years, and during the last few years especially, very considerably, but the precise quantities have not been ascertained. She has never figured high as an exporter of coals; indeed, she imports from England about 500,000 tons of coal and coke yearly. During the last few years the Prussian coal-owners have found it impossible to supply the increasing local demand, and prices have gone up several shillings per ton in consequence; and as Prussia contains some twenty-three ports at which coals can be discharged, it is found remunerative to import from England. Prussian coal generally is worked at about half the cost of French coal, and the probability is that, in a few years, the large capital which is being invested in mining operations, the high price of iron and coal, and the transit facilities afforded by the railroads and canals, complete and incomplete, and rivers, upon which, though they possess slight advantages of tidal water, goods are carried at a low figure, will enable the producers to overcome the local demand. The vicinity of the Prussian coal-fields to France is exceedingly favourable to an increased export of coals thither, if a surplus quantity could be obtained, and the obnoxious impost upon this important article of commerce entering France were abolished. In the Ruhrort district coals are obtained at a similar cost to that incurred in the Liege district, Belgium, from which, indeed, it is only about eighty miles distant. Already a dozen collieries are in operation in the Ruhrort field, and two or three others are underway, while in the Dortmund district, a little to the east of Ruhrort, no fewer than fifty-eight pits have been opened, and nine others are being commenced; so that in a little time we may anticipate a largely increased production, enabling the Prussian proprietors to compete with Belgium and England, by exporting much more extensively than they have hitherto. In means of transit Ruhrort is highly

favored. It is the centrepoint of railways, which branch off in all directions to Antwerp, Rotterdam, Amsterdam, and ports in Denmark and through Germany generally. At the present time, although the productive power of Prussia is something below that of Belgium, she is almost wholly independent of foreign purchasers, whereas Belgium every year requires an outlet for about half of her production. The railways and other great works which are being executed in Prussia and other parts of Germany create an extensive and increasing demand for the coal and valuable ironstone in which Prussia abounds, and in these respects renders her almost independent of the rest of Europe for *materiel* of that description.

Spain produces coal for her own use, but, having no fewer than one hundred and six ports* round her coast, almost as easy of access to English vessels, and vessels trading with England, as are the ports of France and Belgium, she imports coals and large quantities of coke from England, amounting to not less than 300,000 tons per annum. In consequence of her richness in other minerals, such as lead, copper, &c., which are cheaply and easily worked, she is now the largest importing country in the world for coke (used chiefly for smelting purposes), which is supplied to her from the North of England. Ironstone is found in considerable quantities in Spain, but, up to the present time, its working has not been attended with any noticeable measure of success. The Company known as the Asturian Company, composed principally of English capitalists, expended large sums of money in establishing ironworks in the northern part of the country, but failed to realise their expectations of a profitable return for their money. Indeed, the original shareholders lost nearly all they embarked in the concern. The principal reason of the failure is attributable to the absence of the different qualities of stone required for the manufacture of good metal. It has been said that the ingredients necessary for a proper admixture, might have

* The number of ports accessible for commercial purposes in the under-mentioned countries are as follows:—

			Ports.	
France			138	
Spain			106	
Prussia			27	
Belgium			13	
Holland			90	
Denmark			209	
			583	
Other countries	74	in number	1706	
Total	80		2289	(*See Appendix.*)

been obtained from England, but it is questionable whether, under any circumstances, iron could have been manufactured so cheap as it could have been supplied from England.

[illegible] OF THE TRADE FROM 1850 TO 1856, BOTH INCLUSIVE.

[illegible]owing table presents, in a condensed form, the progress of the [illegible]nch coal trade during the seven years ending 1856:—

PROGRESS OF THE EXTRACTION OF NATIVE COAL IN FRANCE DURING THE LAST SEVEN YEARS.

Years.	Quantities produced.	Increase since 1850.	Increase per Cent.	Increase since 1851.	Increase per Cent.	Increase since 1852.	Increase per Cent.	Increase since 1853.	Increase per Cent.	Increase since 1854.	Increase per Cent.	Increase since 1855.	Increase per Cent.
	Tons.	Tons.		Tons.		Tons.		Tons.		Tons.		Tons.	
1850	4,433,570												
1851	4,485,033	51,463	11										
1852	4,903,925	470,355	10½	418,892	9								
1853	5,928,877	1,495,307	32½	443,844	10	1,024,952	20						
1854	6,827,007	2,393,437	50	2,341,974	52	1,923,082	40	898,130	15				
1855	7,453,048	3,019,472	64	2,968,015	63	2,549,123	51	1,524,171	26	626,641	9		
1856	7,740,317	3,286,741	75	3,255,284	74	2,836,392	57½	1,811,440	31	913,310	13	287,269	4

The table annexed exhibits in the same manner the progress of the importation of foreign coals into France during the same period.

PROGRESS OF THE IMPORTATION OF COALS INTO FRANCE DURING THE LAST SEVEN YEARS.

Years.	Quantities Imported.	Increase since 1850.	Per Centage of Increase.	Increase since 1851.	Per Centage of Increase.	Increase since 1852.	Per Centage of Increase.	Increase since 1853.	Per Centage of Increase	Increase since 1854.	Per Centage of Increase.	Increase since 1855.	Per Centage of Increase.
	Tons.	Tons.		Tons.		Tons.		Tons.		Tons.		Tons.	
1850	2,833,262												
1851	2,926,585	93,323	3½										
1852	3,095,934	262,672	9¼	169,349	5½								
1853	3,530,533	694,271	25	603,948	20½	434,599	14						
1854	4,129,988	1,296,726	41	1,203,403	41¼	1,034,054	33½	599,458	17				
1855	4,952,214	2,118,952	75	2,025,629	69	1,856,280	60	1,421,681	40	822,226	20		
1856	5,069,999	2,236,737	80	2,143,414	72½	1,974,065	63	1,539,466	43½	940,011	22½	117,785	2½

These tables and the preceding statements show that France is the largest coal-importing country in the world, and prove the remark with which I commenced, that she ranks next to Great Britain as a coal-consuming country. What she may become in the course of a few years time only can show.

CHAPTER II.

THE FRENCH COAL FIELD.

The present extent of the French coal field is estimated at 920 square miles. It stretches over no fewer than forty-five departments—small patches of coal appearing here and there—and comprises 448 mines. The following table gives the number of mines in each separate department, together with the production of each of the latter in the year 1852:—

Departments.	No. of Mines.	Production in 1852.	Departments.	Number of Mines. Each.	Number of Mines. Total	Production in 1852.
		Tons.				Tons.
			Brought up		396	4,685,228
Loire	70	1,639,183	Vaucluse	..	..	7,150
Gard	45	386,007	Aude	..	..	2,020
Aveyron	33	182,825	Creuse	5	25	4,320
Isère	26	83,368	Cantal	..	..	580
Hérault	24	50,362	Vendée	..	..	12,290
Lower Alps	22	3,183	Lower Loire	3	6	15,093
Saône and Loire	22	528,059	Corrèze			5,399
Nord	20	1,072,845	Tarn	..	..	62,192
Mouths of the Rhône..	19	105,500	Lower Rhine	..	..	10,210
Upper Alps	17	4,720	Rhône	2	10	17,734
Allier	15	256,467	Drôme			
Mayenne	10	85,430	Finistère			
Var	10	469	Calvados	..	..	24,906
Maine and Loire	9	43,877	Nièvre	..	..	73,934
Upper Loire	9	43,732	Manche			
Upper Saône	8	56,966	Moselle			
Straits of Calais	8	37,069	Yonne			
Puy de Dôme	8	29,766	Dordogne	1	11	
Ardèche.	7	15,359	Jura			
Sarthe	6	28,038	The Two Sèvres ..	..	..	12,940
Vosges	4	1,245	Doubs			
Ain	4	457	Landes			
			Eastern Pyrénées..	..	..	200
	396	4,685,228			448	4,934,196

The present number of coal fields in France is sixty-two, but some of them (as will be seen on a reference to the map, where their size and position are indicated by black spots) are very unimportant. By far the largest are those of Loire and Valenciennes, the former situated in the department of that name, and the latter in the Nord department. These may, not inaptly, be termed the Durham and Northumberland of France: more than half the annual production is extracted from thence. They unitedly employ labour to the extent of 16,000 hands, at an annual outlay of £410,000, or £25 per man, producing 2,703,980 tons. As a pleasing contrast, it may be mentioned that the same number of English hands would raise eight million tons, for at the present time the coal extracted per year in the North of England is 16,500,000

tons, raised by 34,000 miners. Our men, of course, are more expert and better paid than the French, which may, to some extent, account for the difference.

The following table shows the produce of ten of the principal of the French coal fields for the years 1847, 1848, and 1852:—

QUANTITY AND QUALITY OF COAL EXTRACTED FROM TEN PRINCIPAL BASINS IN 1847, 1848, AND 1852.

Name of Basin.	Quantity of Coal extracted.	Quantity produced.		
		1847.	1848.	1852.
		Tons.	Tons.	Tons.
Loire	Bituminous	1,712,330	1,323,030	1,631,130
Valenciennes	Ditto	1,245,651	927,310	1,072,850
Alais	Ditto	457,579	353,160	385,160
Creusot and Blanzy	Ditto	389,696	284,640	405,730
Aubin	Ditto	211,744	126,640	171,030
Commentry	Ditto	194,702	160,120	220,970
Epinac	Ditto	110,886	77,500	104,370
Maine	Anthracite	104,481	90,950	101,010
Aix	Lignite	98,570	89,400	103,630
Ronchamp	Bituminous	90,000	75,010	85,000
		4,604,639	3,507,760	4,280,880
The fifty-two remaining fields, producing on the average for the six years, not more than 100,000 tons per annum	.....	548,565	492,673	623,045
	Total....	5,153,204	4,000,433	4,903,925

Varieties of French Coal.

In one of my former papers, I entered at some length into the different varieties of coal afforded by the Great North of England fields, and as the subject is both important and interesting, I purpose to devote some space to the consideration of the various qualities of the French coal. These are six in number, namely, anthracite, lignite, and four varieties of bituminous coal, classed as follows: — Free-burning smithy coal* (*houille grasse à longue flamme*), yielding about 70 per cent. of coke when calcined in a close oven; close-burning coal (*houille maigre a longue flamme*), yielding about 60 per cent. of coke; common smithy coal (*houille grasse maréchale*), producing full 70 per cent of coke; and the hard coal (*houille dure a courte flamme*), which gives as much as 75 per cent. of coke.

* This coal, of all the other French varieties, most nearly resembles the tender coking or fine bituminous English coal, which, in consequence of its freedom from shale and pyrites, and its general purity, is so much in demand for gas, coking, smithy, and other important purposes.

Of these varieties, in no one instance are all six found in one department. Loire, the principal district, lacks lignite, and Gard yields no anthracite, although each of these departments contains the other five varieties. Creuse lacks both lignite and anthracite, but contains every variety of the bituminous coal; while Saône and Loire, a department which contributes to the general production 500,000 tons a-year, yields neither anthracite, lignite, nor the common smithy coal.

The distribution of the different varieties over the whole empire will be seen in form in the annexed table:—

TABULAR STATEMENT OF THE QUALITY OF COAL FOUND IN THE DIFFERENT COAL-PRODUCING DEPARTMENTS.

Nature of the Coal.	Number of Departments in which found.	Names of Departments.
Pure anthracite	2	Sarthe, Upper Alps.
Anthracite and 1 bituminous variety..	5	Nord, Lower Loire, Calvados, Maine and Loire, Mayenne.
Ditto and 2 ditto ..	1	Allier.
Ditto and 3 ditto ..	1	Puy de Dôme.
Ditto and 4 ditto ..	1	Loire.
Ditto and lignite	1	Isère.
Ditto and 2 bituminous varieties..	1	Hérault.
Lignite only	7	Mouths of the Rhône, Ain, Lower Alps, Vaucluse, Var, Lower Rhine, Eastern Pyrénées.
Ditto and 1 bituminous variety	2	Upper Saône, Aude.
Ditto and 2 ditto	1	Ardèche.
Ditto and 3 ditto	1	Aveyron.
Ditto and 4 ditto	1	Gard.
One bituminous variety only	5	The Two Sèvres, Nièvre, Rhône, Tarn, Vosges.
Two ditto ditto	6	Saône and Loire, Cantal, Corrèze, Straits of Calais, Upper Loire, Vendèe.
Four ditto ditto	1	Creuse.

Progress of the Extraction of the Free-burning Smithy Coal.

The variety most in demand during the septennial period ending 1852 was the free-burning smithy coal, of which the average yearly production was 2,200,000 tons. Like the anthracite, it is found in great abundance in the Loire department, no fewer than 1,065,908 tons—55 per cent. on the total yield of the variety, or a fourth part of the whole produce—having been obtained there in the year referred to.

The subjoined table presents, at one view, the departmental extraction of the free-burning smithy coal, and its value. I have selected the

years annexed, because they exhibit the progress of the production more fairly than any other; the year 1847 showing the state of the extraction as it existed before the disturbances of 1848, the next year exhibiting the depression which the trade sustained, as already largely spoken of, and and the year 1852 as forming a sort of middle stage between the revolutionary period and the present time. It is a noticeable fact that the trade in this variety of coal suffered more severely from internal confusion than any of the others.

TABULAR STATEMENT OF THE EXTRACTION AND VALUE OF THE FREE-BURNING SMITHY COAL.

Departments.	1852.		1848.		1847.	
	Production.	Value.	Production.	Value.	Production.	Value.
	Tons.	£	Tons.	£	Tons.	£
Loire	1,068,708	335,300	920,273	318,053	1,262,951	443,277
Nord	645,825	299,385	590,215	284,920	818,222	506,116
Gard	202,569	54,867	134,648	36,282	228,527	61,323
Saône and Loire	182,284	73,119	3,031	1,189	2,723	1,087
Aveyron	176,038	45,640	131,001	32,488	217,484	45,715
Tarn	62,192	33,115	34,392	19,933	42,744	22,872
Upper Loire	40,454	15,071	8,522	3,361		
Hérault	23,012	11,716	8,000	4,472	9,240	5,021
The Two Sèvres	12,940	5,617	9,340	4,016	9,711	4,035
Mayenne	12,456	9,815	....	....	11,396	9,254
Ardèche	11,627	3,532	6,431	2,407	6,021	2,323
Straits of Calais	9,128	5,701	3,102	1,737	1,963	1,182
Vendée	7,336	2,935				
Var	7,201	3,025	....	....	1,698	678
Allier	2,653	1,074	10,558	5,122	10,735	4,880
Creuse	1,245	561	2,231	947		
Calvados	870	545				
Cantal	480	179	250	150	32	20
	2,467,023	902,197	1,871,800	715,171	2,623,794	1,107,789
Mean price per ton	....	7s. 4d.	....	7s. 7d.	....	8s. 5½d.

Progress of the Yield of Close-burning Coal.

The next most abundant variety is the close-burning coal, of which there was raised, in 1852, 914,115 tons, an increase over the extraction of the previous year of about 400,000 tons, but 600,000 tons less than the yield of 1850. In 1847 the total produce was estimated at 885,259 tons, which was reduced in 1848 to 675,559 tons. Seventeen districts contain beds of this variety in greater or less proportion. The principal are Saône and Loire, Allier, and Loire, the first-named alone having furnished, in 1852, 345,775 tons, more than one-third of the total produce of the kind. The tabular statement of the production and value of this variety is as follows:—

TABULAR STATEMENT OF THE YIELD AND VALUE OF CLOSE-BURNING SMITHY COAL.

Departments.	1852.		1848.		1847.	
	Production.	Value.	Production.	Value.	Production.	Value.
	Tons.	£	Tons.	£	Tons.	£
Saône and Loire ..	345,775	123,880	273,757	971,553	396,172	143,069
Allier	243,996	73,542	176,900	55,890	214,278	65,157
Loire	161,709	55,692	100,220	33,107	132,521	41,480
Nièvre	73,934	31,821	50,315	24,457	67,115	36,321
Straits of Calais ..	27,941	13,237	14,572	8,473	17,650	10,681
Rhône	17,734	8,056	16,823	7,735	19,937	7,927
Hérault	16,389	4,587	15,141	6,487	14,311	5,937
Puy de Dôme ...	13,378	3,692	20,877	6,098	16,668	5,584
Vendée	4,955	1,790				
Corrèze	3,344	1,785	1,078	906		
Ardèche	2,982	2,173	3,276	2,482	3,385	2,559
Aude	1,002	497	915	543	1,068	428
Aveyron	522	4,488				
Creuse	402	120	5	2½		
Gard	187	68	773	470	549	594
Lower Rhine	..	..	856	84	176	177
Vosges	..	..	797	472	1,378	823
	914,155	320,740	675,559	244,755	885,259	320,838
Mean price per ton	....	7s. 2¾d.	....	7s. 3d.	....	7s. 4d.

The Extraction of Anthracite Coal.

The French anthracite is principally raised in the departments of Nord, Mayenne, Calvados, Isere, Maine and Loire, and Sarthe. The whole production in 1852 was 691,534 tons, 12 per cent. on the extraction of all kinds. The increase since 1848 has been, on the average, 39,324 tons a-year, or an aggregate augmentation of 149,295 tons.

TABULAR STATEMENT OF THE YIELD AND VALUE OF ANTHRACITE.

Departments.	1852.		1848.		1847.	
	Production.	Value.	Production.	Value.	Production.	Value.
	Tons.	£	Tons.	£	Tons.	£
Nord	427.020	169,025	337,096	138,816	427,429	182,613
Mayenne	72,974	54,807	59,235	52,376	61,610	50,129
Isère	55,084	17,341	40,962	12,477	42,933	13,148
Maine and Loire ..	42,989	30,032	10,353	5,880	4,000	3,250
Sarthe	28,038	24,628	40,099	30,329	42,871	30,693
Calvados	24,036	13,376	29,261	16,854	41,444	23,933
Lower Loire	12,986	7,420	6,699	5,402	11,655	7,650
Loire	8,951	2,302	3,662	1,175	10,246	2,412
Allier	5,269	1,559	4,263	1,232	3,668	1,202
Puy de Dôme	4,909	1,867	770	147	2,216	648
Upper Alps	4,720	520	4,555	957	5,101	1,101
Hérault	4,554	1,520	4,572	1,156	4,543	2,246
Creuse	..	..	..	..	700	406
Var	..	..	709	302	530	254
	691,534	324,807	542,239	267,102	659,029	319,957
Average price per t.	....	9s. 4½d.	....	9s. 10¼d.	....	9s. 8½d.

The Extraction of Common Smithy Coal.

Fourth in the order of priority comes the common smithy coal. The production of this variety was, in 1852, 464,748 tons, at about which figure it had stood, with the single exception of the year 1850, for the previous seven years. Only six out of the eighty-six departments into which France is divided contribute this species of the bituminous coal; and in the production of this variety, as in that of most of the others, Loire takes first rank. Not less than three-fourths of the total extraction of the common smithy coal was furnished by this department. The produce of the other districts is unimportant, as will be found in the table.

One peculiar feature of this species of coal is the very inflated (*bour soufflè*) nature of the coke obtained from it. None of the other varieties possess this quality to any extent; indeed, the free-burning smithy is the only other kind which exhibits it at all. Subjoined is the tabular statement:—

TABLE SHOWING THE EXTRACTION AND VALUE OF THE COMMON SMITHY COAL.

Departments.	1852.		1848.		1847.	
	Production.	Value.	Production.	Value.	Production.	Value.
	Tons.	£	Tons.	£	Tons.	£
Loire	373,683	137,760	302,531	128,204	316,866	124,511
Gard	84,913	33,657	76,788	28,003	104,046	32,304
Aveyron	2,073	686				
Corrèze	2,055	2,144	1,615	1,850	1,733	1,500
Creuse	1,219	747	1,402	800	3,082	1,572
Puy de Dôme	804	225	50	26	55	28
Hérault	..	..	4,810	2,790	4,552	2,454
Upper Loire	..	..	..	..	5,310	1,861
Saône and Loire..	..	..	2,444	581,178	2,123	21,195
	464,748	175,220	448,297	179,920	489,716	185,827
Average price per t.	....	7s. 6d.	....	8s. 0¼d.	....	7s. 7d.

Progress of the Production of Lignite, &c.

Next in the list stands the lignite, so called from its semi-decomposed nature, and the actual presence of the distinct woody fibre, a variety not very extensively found in this country. With its production is incorporated that of the stipite, a variety of coal distinguished from the lignite by a grass-like fibre. The aggregate yearly production of the

whole does not exceed 200,000 tons. It is chiefly met with in the department of the Mouths of the Rhone, where, indeed, almost the whole vend is procured. Thirteen other departments certainly yield a portion, but so inconsiderable is it that it scarcely deserves notice. The quantity raised from all sources in 1852 was only 191,818 tons, and of this the Mouths of the Rhone department contributed 105,500 tons, or 81¾ per cent. The trade in lignite has undergone less variation from revolutionary struggles and vicissitudes of commerce than that of any other variety, owing, probably, to the fact of its being chiefly used by the lower classes in lieu of wood.

The tabular statement of the production of lignite, &c., during the period over which our calculations extend is as follows:—

TABULAR STATEMENT OF THE YIELD AND VALUE OF LIGNITE.

Departments.	1852.		1848.		1847.	
	Production.	Value.	Production.	Value.	Production.	Value.
	Tons.	£	Tons.	£	Tons.	£
Mouths of the Rhône	105,500	48,152	89,001	43,243	92,189	47,497
Isère	28,362	11,095	23,712	11,382	20,830	9,999
Gard	12,477	4,152	11,223	4,199	13,187	4,845
Upper Saône	11,503	5,081	9,307	4,272	10,511	5,418
Lower Rhine	10,210	3,100	6,498	1,886	8,085	2,858
Vaucluse	7,151	1,344	9,660	1,659	10,852	1,233
Hérault	6,405	3,116	6,330	3,530	4,707	2,499
Aveyron	4,191	1,494	3,996	1,813	4,457	1,731
Lower Alps	3,183	962	3,451	1,055	4,330	1,124
Aude	1,017	621	1,099	623	1,264	677
Ardèche	750	162	650	117	554	101
Var	469	187	....	....	1,780	654
Ain	457	99	....	....	899	268
Eastern Pyrénées..	200	100				
Aisne	....	....	340	33	700	78
Doubs	....	....	330	165	80	29
Landes	....	....	....	....	450	226
Moselle	....	....	....	....	150	51
	191,818	79,667	165,601	73,989	174,930	79,690
Mean price per ton	....	8s. 2½d.	....	8s. 11¼d.	....	9s. 1¾d.

The Extraction of Hard Coal.

Sixth and last in the order of production stands the hard coal, which is found in nine departments. A peculiar feature of the trade in this variety is its gradual declination since the revolutionary year, for which the Minister of Commerce, in chronicling the circumstance, offers no

explanation. Probably the absence of suitable grates, hearths, and other apparatus for consuming coal of so hard a nature, joined with ignorance of a proper mode of firing it, caused the variety to fall into disrepute, and thus led to its disuse. In the year 1847, a total yield of 320,473 tons is recorded; in the year 1848 it had fallen to 296,933 tons; and in 1852 there was a still further decline, the total yield in that year being under 180,000 tons. In 1847, the extraction was greater by 145,543 tons than that of lignite; in the last-named year it was less by 17,173 tons than the lignite yield—less, indeed, by nearly 300 tons, than the extraction of the latter variety in 1847. From the department of Hérault, the supply entirely ceased in 1850; and in the Gard department it dwindled from 120,984 tons in 1847, to 85,859 tons in 1852. Indeed, during the revolutionary period of 1848, and in succeeding years down to 1852, Loire is not credited for one ounce of hard coal; and Creuse, which, in 1847, furnished 600 tons, produced none in 1848, and only about 45 tons in 1852.

TABULAR STATEMENT OF THE EXTRACTION OF HARD COAL.

Departments.	1852.		1848.		1847.	
	Production.	Value.	Production	Value.	Production.	Value.
	Tons.	£	Tons.	£	Tons.	£
Gard	85,859	25,972	134,874	41,195	120,984	33,674
Upper Saône	45,462	26,821	227,388	13,152	21,824	14,185
Loire	26,130	8,244				
Puy de Dôme	10,774	3,720	16,489	6,583	8,125	3,592
Upper Loire	3,278	1,293	157,868	6,140	31,654	11,843
Lower Loire	2,106	1,390	4,058	3,456	6,202	5,662
Maine and Loire ..	887	849	43,611	31,175	37,365	34,135
Cantal	100	40				
Hérault	..	..	7,000	2,800	5,116	2,073
Saône and Loire ..	..	..	43,707	16,629	72,908	28,580
Vendée	..	..	8,482	5,225	13,558	7,494
Creuse.....	46	23	..	..	602	289
Aveyron	..	..	186	125	2,181	868
	174,644	68,352	296,933	126,482	320,473	142,398
Mean price per ton	....	7s. 10d.	....	8s. 6½d.	....	8s. 11½d.

TOTAL EXTRACTION AND VALUE OF EACH VARIETY.

The aggregate proportion of each variety of coal extracted in France, with the total value of each separate species, during the years beforementioned, is presented below :—

PRODUCTION, VALUE, AND AVERAGE PRICE PER TON OF THE DIFFERENT SORTS.

Nature of the Coal.	1852.		1848.		1847.	
	Production.	Value.	Production.	Value.	Production.	Value.
	Tons.	£	Tons.	£	Tons.	£
Bituminous. Free-burning smithy coal..	2,467,023	901,285	1,871,800	717,751	2,623,794	1,008,207
Bituminous. Close-burning ditto	914,155	320,740	675,559	244,755	885,259	324,839
Bituminous. Common smithy coal..	464,748	175,220	448,297	179,920	489,716	186,627
Hard coal	174,644	68,352	296,933	126,482	320,473	142,398
Anthracite....	691,534	324,807	542,239	267,113	659,029	319,957
Lignite, stipite.	191,818	79,667	165,601	73,989	174,930	7,910
Total	4,903,925	1,870,072	4,000,433	1,810,000	5,153,234	2,056,920
Average price ..	....	7s. 7¾d.	....	8s. 6d.	....	8s.

Amount of Labour Employed and Wages Paid to Labourers in the French Coal Mines.

In preceding pages, concurrently with the progress or decline of the French trade, I have given statistics of the amount of labour employed in mining operations. I now take ten of the principal coal-yielding departments, and give the number of hands engaged in each of them during the period to which the preceding tables refer, from which an accurate idea of the state of labour and its proportion to the total yield may be gathered.

TABULAR STATEMENT OF LABOUR AND WAGES FOR 1852.

Departments.	Workmen employed.			Estimate of Wages paid.	Average Wages per Man.	Total Production.	Average Production per Man.
	In the Pit.	Above-ground.	Total.				
				£	£ s.	Tons.	Tons.
Nord	8,580	1,612	10,192	216,601	21 9	1,072,845	105
Loire	4,889	1,835	6,724	195,126	29 0	1,639,183	244
Saône and Loire ..	2,322	1,227	3,549	81,113	22 17	528,059	148
Gard	1,722	593	2,315	58,182	25 6	386,007	166
Allier	1,396	869	2,265	36,526	16 5	256,467	113
Upper Saône	752	216	968	17,810	18 9	56,966	59
Mouths of the Rhone	902	57	959	19,000	19 16	105,500	110
Aveyron	664	275	939	20,558	22 10	182,825	193
Mayenne	719	196	915	19,187	20 17	35,430	38
Nièvre	490	135	625	14,927	23 17	73,734	117

TABULAR STATEMENT OF LABOUR AND WAGES FOR 1848.

Departments.	Workmen employed.			Estimate of Wages paid.	Average Wages per Man.	Total Production.	Average Production per Man.
	In the Pit.	Above-ground.	Total.				
				£	£ s.	Tons.	Tons.
Nord	7,991	1,582	9,573	196,493	20 10	927,311	97
Loire	5,161	1,792	6,953	156,265	22 9	1,326,687	192
Saône and Loire	1,759	868	2,627	60,631	23 2	381,595	145
Gard	1,291	231	1,522	46,520	30 11	358,307	234
Allier	1,085	667	1,752	27,648	15 15	191,721	109
Upper Saône	367	122	489	7,526	15 8	32,046	66
Mouths of the Rhône	851		851	21,961	25 16	89,001	104
Aveyron	525	233	758	22,019	29 3	135,184	178
Mayenne	759	233	902	21,803	21 19	59.235	55
Nièvre	360	187	547	12,780	23 8	50,315	90

TABULAR STATEMENT OF LABOUR AND WAGES FOR 1847.

Departments.	Workmen employed.			Estimate of Wages paid.	Average Wages per Man.	Total Production.	Average Production per Man.
	In the Pit.	Above-ground.	Total Workmn.				
				£	£ s.	Tons.	Tons.
Nord	8,199	1,925	10,124	215,491	21 5	1,245,651	123
Loire	5,415	1,082	7,217	229,587	31 16	1,722,585	238
Saône and Loire	2,080	788	2,868	73,168	25 10	525,874	183
Gard	1,872	396	2,268	68,611	30 4	467,339	206
Allier	1,115	689	1,804	30,040	16 13	228,683	126
Upper Saône	379	100	479	7,986	16 9	32,326	67
Mouths of the Rhône	1,037	....	1,037	21,798	21 0	92,089	89
Aveyron	875	365	1,240	31,653	25 10	224,073	180
Mayenne	791	260	1,051	23,799	22 13	73,066	69
Nièvre	435	150	585	14,040	24 0	67,115	114

The French Export Trade in Coal.

Large as is the importation of foreign coal, and extensive as it is likely to continue for many years to come, there has always been an export coal trade from France, though, of course, to only a very limited extent. Her foreign consignments, whether of native coal or of coal originally imported, have never exceeded 60,000 tons, and, up to the year 1845, they were below 50,000 tons. In the year 1848, the whole export was only 48,921 tons, distributed amongst the undermentioned countries, namely :—

	Tons.
Switzerland	10,491
Sardinia	6,874
Belgium	8,244
Algeria	15,108
Spain	491
French Colonies	1,137
Tuscany	548
Germany	444
Turkey	1,586
Sweden	3,161
Various Countries	832
Total	48,921

Since that time some increase in the trade has taken place, the total quantity of coals and coke exported, down to the end of 1856, having been :—

	Tons.
1850	41,564
1852	41,366
1853	46,113
1854	100,210
1855	111,576
1856	99,496

These exportations take place chiefly from the coal basins of Loire, Valenciennes, and Aix. Southern Switzerland is, to a great extent, supplied with Loire coal, which is also sent in small quantities to Sardinia and Algeria. The Valenciennes portion is taken into Belgium, and that of Aix is chiefly exported to Sardinia. English coal is re-exported to Algeria and other French colonies, but the quantity so disposed of does not exceed 8,000 tons a-year, most of the English coal consumed in Algeria being sent thither direct.

Resume of Home and Foreign Supplies.

I conclude this portion of the paper by summarising the facts elucidated in the foregoing pages. The following abstract shows the native yield and the foreign importation for nearly a century :—

TABULAR STATEMENT OF THE PRODUCTION OF NATIVE COAL, AND THE IMPORTATION OF FOREIGN COAL INTO FRANCE, FROM THE YEAR 1787 TO THE PRESENT TIME.

Years.	Native Production.	Foreign Importation.					Total Native and Foreign Supply.
		Belgium.	England.	Prussia.	Other Countries.	Total.	
	Tons.	Tons.	Tons	Tons.	Tons.	Tons.	Tons.
1787	215,000	50,000	154,378	10,000	....	214,378	429,378
1788	225,000	51,615	164,773	12,000	....	228,388	453,388
1789	240,000	50,000	180,000	10,000	....	240,000	480,000
1802	844,180	85,000	10,000	18,000	....	113,000	957,180
1811	773,694	95,000	....	25,000	....	120,000	893,694
1812	835,523	98,000	....	26,000	....	124,000	959,523
1813	771,779	90,500	....	27,000	....	117,000	888,779
1814	788,371	125,053	11,392	28,000	....	164,445	952,816
1815	881,587	198,462	22,432	28,500	....	249,394	1,130,981
1816	941,638	272,014	19,050	29,500	....	320,564	1,262,202
1817	1,003,380	192,742	15,775	50,334	....	258,851	1,262,231
1818	897,904	208,022	23,809	49,513	506	281,851	1,179,755
1819	964,009	170,045	23,991	42,359	371	236,766	1,200,775
1820	1,093,657	227,212	25,119	27,814	773	280,919	1,374,576
1821	1,134,711	251,801	31,105	38,524	163	321,593	1,456,304
1822	1,193,578	267,777	31,105	39,179	6	338,069	1,531,647
1823	1,195,227	264,873	23,232	38,704	5	326,926	1,522,553
1824	1,325,699	394,431	25,452	42,238	56	462,179	1,787,878
1825	1,491,581	439,248	26,684	42,393	292	508,618	2,000,199
1826	1,541,000	410,611	36,942	57,454	172	505,179	2,046,179
1827	1,691,075	423,224	47,780	70,825	184	542,015	2,233,091
1828	1,774,073	470,869	35,836	77,223	119	584,048	2,358,121
1829	1,741,570	435,947	42,843	75,612	21	554,425	2,295,995
1830	1,862,665	510,806	51,128	75,341	13	637,288	2,499,953
1831	1,760,385	443,549	35,911	68,924	23	548,407	2,308,792
1832	1,962,855	489,480	37,530	52,619	160	579,789	2,542,644
1833	2,057,631	580,171	42,640	79,185	350	702,349	2,759,980
1834	2,489,840	620,176	48,943	78,039	24	747,183	3,237,023
1835	2,506,416	615,157	98,159	89,738	21	803,075	3,309,491
1836	2,841,946	715,871	169,569	113,836	184	999,451	3,841,397
1837	2,980,735	788,413	222,005	132,673	312	1,143,403	4,124,138
1838	3,113,252	796,457	304,684	125,137	750	1,227,030	4,340,282
1839	2,994,861	740,810	310,527	156,913	493	1,208,743	4,203,604
1840	3,003,382	748,600	380,773	160,779	506	1,290,660	4,294,042
1841	3,410,199	992,225	429,949	196 502	482	1,619,159	5,029,358
1842	3,592,084	977,934	490,738	199,695	815	1,669,138	5,261,222
1843	3,692,539	991,860	455,662	213,014	2,150	1,662,687	5,355,226
1844	3,782,739	1,115,794	427,693	299,036	3,360	1,845,883	5,628,622
1845	4,202,091	1,396,166	560,748	240,693	4,584	2,202,191	6,404,282
1846	4,469,342	1,350,206	611,301	228,405	4,009	2,193,922	6,663,264
1847	5,153,204	1,686,990	586,520	272,330	2,880	2,548,720	7,701,924
1848	4,000,433	1,399,380	514,920	227,090	2,380	2,143,770	6,144,203
1849	4,049,220	1,591,320	572,140	228,720	1,770	2,393,950	6,443,170
1850	4,433,570	1,953,190	602,410	277,280	380	2,833,260	7,266,830
1851	4,485,033	2,025,990	602,230	298,200	260	2,926,680	7,411,713
1852	4,903,925	2,119,180	652,390	324,260	130	3,095,960	7,999,885
1853	5,928,877	2,456,959	703,704	369,734	136	3,530,533	9,459,410
1854	6,827,007	2,856,146	780,449	492,989	404	4,129,988	10,956,995
1855	7,453,048	3,327,333	953,990	670 045	846	4,952,214	12,405,262
1856	7,740,317	3,119,620	1,165,878	781,521	2,970	5,069,999	12,810,316

Since the year 1821 the importation of coke is included in the returns.

CHAPTER III.

CONSUMPTION OF COAL IN FRANCE FROM 1847 TO 1856 BOTH INCLUSIVE.

Having, in the two preceding chapters, so extensively treated upon the production of coal in France, I fear it would be trenching too much on the time and patience of the members of the Institute were I to go to as great a length in placing before them the history and progress of the consumption of coal in that country. But, as the subject is of too much importance to be omitted altogether, and as, probably, many of you may be interested to know in what proportion English and Belgian and native French coal is consumed in the principal manufacturing departments, as well as the various cities and towns of France, a very brief summary of the state of that branch of our subject is annexed, accompanied by a map, which shows not only the size, and shape, and amount of the productions of the different coal-fields, but also the consumption of every kind of coal, and the proportion in which each is consumed.

I shall commence with 1847, as the figures of consumption from that year to the present will serve every purpose of exhibiting the quantities consumed, and the places of disposition. It will also show, by the chief points of competition between the native variety and the aggregate of foreign coal on the one hand, and between different exporting countries on the other.

The departments which have consumed the most each year are those of Nord, Loire, Seine, Straits of Calais, Rhône, Saône and Loire, and Gard. In the department of Nord there were consumed in 1847, 1,567,370 tons, fully one-fifth of the total production of France. In 1848 Nord fell to 1,368,240 tons, or 32 per cent.; in 1849 still lower, the quantity disposed of being only 1,261,780 tons. By the end of 1850 it was only a few tons over the consumption of 1848; in 1851 only a few tons more; while even in 1852 it had not reached the point from which it fell in 1847.

The consumption in the department of Loire, in the year 1847, amounted to 616,870 tons; during the revolutionary period it fell to 592,970 tons. In 1849, like Nord, it descended still lower, the quantity consumed being only 534,490 tons; in 1850 it gained a most important advance, rising suddenly, as it were, to 643,660 tons; in 1851 the consumption fell off slightly, but was still greater than it was in 1847;

while, in 1852, 702,700 tons were taken into consumption, better than 100,000 tons more than was disposed of in the district in the year preceding that of the revolution.

The department next highest in the list, is the Seine, where in 1847, 499,650 tons were used; in 1848 the consumption fell to 344,010 tons; in 1849 it sprung up to 513,680 tons; in 1850 to 653,960 tons; in 1851 it descended to 646,870 tons; and in 1852 an augmentation was realized, making the total consumption 662,830 tons.

After these three departments, which, as it will be seen, consume upwards of a third of the total quantity used over the whole empire, come the departments of the Straits of Calais, Rhône, and Saône and Loire, the general consumption of which has been better than 350,000 tons per year. Gard consumed in 1847, 346,640 tons, but in 1849 the returns exhibit a falling off to 153,080 tons, and in 1852 the consumption was 98,640 tons less than it was in the first-named year.

Nine other departments have consumed on an average, less than 150,000 tons; eleven less than 100,000 tons; three not more than 75,000 tons; two less than 15,000 tons; and twenty-four less than 10,000 tons. "What" asks M. Magné in his "Resumé des Travaux Statistiques de l'Administration des Mines," published in 1854, "is the cause of the small consumption of this coal in these last named departments? It may, perhaps, be attributed by some to their richness in bituminous coal; by others, to the absence of all industry; but for the greater number I do not hesitate to say that the cause may be found in the lack of means of communication and the high price of transport?"

Departmental Consumption of Native Coal in France.

It may not be altogether devoid of interest to give the relative proportions of the division and dispersion of the French coal throughout the different departments of the empire, and the subjoined table exhibits this distribution from the various fields. It shows that the great basin of Loire furnished coal, in the year 1847, to fifty-one departments; in 1848, to forty-nine; in 1852, to fifty departments (at the same time supplying various foreign countries); that the beds of Valenciennes furnished coal, in 1847, to fourteen departments; in 1848, to fifteen; and in 1852, to sixteen departments, besides exports; that those of Creusot and Blanzy supplied from eighteen to twenty; those of Commentry from thirteen to fifteen; the Alais fields, twelve on the average; that of St. Gervais and the Lower Loire, about six departments.

TABULAR STATEMENT OF THE CONSUMPTION OF COAL EXTRACTED FROM THE BASIN OF THE LOIRE.

Department of Consumption.	1852.	1848.	1847.
	Tons.	Tons.	Tons.
Ain	16,500	8,660	19,580
Allier	200	8,060	220
Upper Alps	600	180	890
Lower Alps	990	680	280
Ardèche	77,600	113,800	183,470
Ariége	300	50	870
Aube	430	3,550	5,490
Aude	800	800	1,150
Mouths of the Rhône	16,880	16,350	19,720
Cher	16,510	9,470	17,630
Córrèze	.....	110	30
Côte d'Or	7,700	10,760	13,870
Doubs	8,620	4,280	12,330
Drôme	27,000	18,450	26,640
Eure	1,600	.....	.....
Eure and Loire	1,650	1,490	2,440
Gard	320	900	15,190
Upper Garonne	1,100	4,450	4,770
Gers	3,000	130	.....
Herault	4,090	3,130	4,240
Indre	460	590	1,290
Indre et Loire	5,920	3,550	5,780
Isère	127,840	87,490	117,560
Jura	5,990	3,150	7,360
Loire	682,240	589,310	604,770
Upper Loire	7,040	4,300	5,220
Loire and Cher	3,180	3,690	6,440
Loiret	12,080	18,250	15,190
Maine and Loire	1,550	720	2,200
Marne	1,200	1,600	2,390
Upper Marne	9,110	9,120	17,620
Mayenne	.....	850	1,060
Meuse	5,870	970	1,210
Nievre	5,440	9,710	8,200
Oise	.....	.....	780
Orne	3,640	1,340	1,670
Puy de Dôme	3,500	2,550	3,180
Upper Pyrénées	200	.....	.....
Eastern Pyrénées	200	110	120
Lower Rhine	8,150	3,600	2,730
Upper Rhine	34,350	19,570	57,710
Rhône	418,800	260,230	358,840
Upper Saône	3,780	2,250	6,090
Saône and Loire	11,400	11,620	16,120
Sarthe	1,500	130	1,780
Seine	19,440	20,500	42,820
Seine and Marne	11,500	6,500	8,990
Seine and Oise	8,500	7,750	8,770
The Two Sèvres	.....	.....	20
Var	12,070	9,740	15,540
Vaucluse	17,500	10,740	21,980
Vienne	610	1,640	1,940
Vendée	600	.....	.....
Vosges	1,180	4,950	7,900
Yonne	3,580	2,550	4,930
Aggregate Consumption	1,610,400	1,309,340	1,686,790
Foreign exportation.			
Switzerland	14,060	8,560	14,560
Algeria	200	2,600	10,040
Germany	.....	4,400	730
Sardinia	5,830	2,060	.....
Various Countries	580	301	280
	20,730	13,090	25,550
Aggregate Production	1,631,130	1,327,261	1,712,540

VALENCIENNES.

Department of Consumption.	1852.	1848.	1847.
	Tons.	Tons.	Tons.
Aisne	116,130	13,970	42,300
Calvados	3,310	630	860
Eure	8,440	17,730	6,130
Eure and Loire	3,370	5,570	610
Loiret	.....	580	4,000
Manche	5,890	5,400	4,906
Upper Marne	16,960	.....	20,470
Meuse	5,520	26,770	.....
Nord	549,840	551,710	759,080
Oise	60,310	21,320	28,170
Straits of Calais	139,870	130,730	147,820
Lower Rhine	1,780	.....	.....
Seine	90,320	119,510	146,380
Seine and Maine	840	1,950	1,230
Seine and Oise	19,540	17,680	11,770
Lower Seine	2,310	2,500	4,900
Somme	40,500	3,300	60,830
Total	1,064,930	919,350	1,239,456
Foreign Exportation.			
Belgium	7,600	7,940	10,200
Other Countries	320	.....	.....
Total Production of Field	1,072,850	927,290	1,249,656

CREUSOT AND BLANZY.

Department of Consumption.	1852.	1848.	1847.
	Tons.	Tons.	Tons.
Ain	4,440	2,880	3,800
Allier	270	1,800	200
Côte d'Or	14,840	5,170	6,750
Doubs	5,740	2,440	2,416
Eure and Loire	....	....	600
Indre and Loire	960	670	510
Jura	9,160	3,430	5,520
Lower Loire	....	1,550	1,360
Loire and Cher	350	140	400
Loiret	1,190	1,500	3,250
Maine and Loire	1,760	450	1,400
Upper Maine	2,050	....	....
Mayenne	220	450	550
Niévre	14,790	18,940	19,430
Upper Rhine	24,640	10,040	31,900
Rhône	25,300	6,120	16,800
Upper Saône	....	....	400
Saône and Loire	282,850	212,540	269,200
Seine	13,820	13,500	18,200
Seine and Marne	2,810	560	3,600
Seine and Oise	490	1,800	1,130
Vienne	60	....	....
Total	405,740	283,960	387,416
Foreign Exportation.			
Switzerland	....	1,800	....
Total Production of Field	405,740	285,760	387,416

Departmental Consumption of Foreign Coal.

TABULAR STATEMENT OF THE DISTRIBUTION OF FOREIGN COAL DURING THE YEARS 1847, 1848, AND 1852.

ENGLISH COAL.

Department of Consumption.	1852.	1848.	1847.
	Tons.	Tons.	Tons.
Mouths of the Rhône	28,150	14,920	29,190
Calvados	44,960	18,310	30,370
Charente	11,250	13,790	4,900
Lower Charente	14,120	14,720	19,580
Corréze	150	.....	.....
Oise	4,780	1,480	700
Côtes du Nord	4,490	5,150	3,760
Dordogne	7,090	3,690	7,510
Eure	12,850	11,510	37,960
Eure and Loire	250	680	150
Finistére	19,400	33,090	15,740
Upper Garonne	2,400	2,070	2,000
Gers	.....	890	.....
Gironde	72,920	56,800	56,960
Hérault	2,230	2,090	1,980
Ille and Vilaine	12,220	10,880	9,320
Indre and Loire	24,020	9,980	8,520
Landes	640	3,070	3,120
Lower Loire	49,090	38,440	62,100
Loiret	.....	300	1,600
Lot and Garonne	3,860	500	3,600
Maine and Loire	3,580	8,650	7,500
Manché	18,400	15,560	26,090
Mayenne	1,800	2,200	3,500
Morbihan	7,370	15,640	2,980
Nord	4,860	3,690	3,250
Oise	14,400	7,880	8,000
Straits of Calais	35,600	31,590	41,820
Lower Pyrénées	2,350	670	630
Eastern Pyrénées	800	100	.....
Sarthe	4,500	2,070	4,500
Seine	1,380	840	.....
Seine and Oise	3,220	.....	200
Lower Seine	220,376	143,930	166,190
The Two Sévres	250	890	1,000
Somme	4,640	8,160	7,190
Var	4,780	7,830	9,280
Vendée	1,800	1,770	2,820
Vienne	1,470	740	650
Upper Vienne	1,040	830	860
Total	645,480	498,500	585,520
Re-exported.			
Sweden	.....	3,160	.....
Tuscany	.....	.....	390
Algeria	5,920	9,710	.....
Belgium	.....	10	20
Turkey	.....	1,590	.....
French Colonies	880	1,140	420
Other Countries	100	810	170
	6,910	16,420	1,000
	652,390	514,920	586,520

BELGIAN COAL.			
Department of Consumption.	1852.	1848.	1847.
	Tons.	Tons.	Tons.
Aisne	78,400	34,760	7,580
Ardennes	84,690	55,150	100,870
Aube	7,830	2,330	.....
Eure	15,000	14,940	2,590
Eure and Loire	900	100	2,340
Gironde	.....	.....	6,600
Indre and Loire	.....	500	.....
Loiret	.....	250	.....
Lower Loire	.....	1,160	1,560
Manché	.....	.....	12,890
Marne	39,700	6,620	.....
Upper Marne	950	.....	.....
Meuse	9,400	2,030	3,200
Morbihan	.....	.....	90
Nord	937,360	812,840	813,640
Oise	81,080	22,180	47,040
Straits of Calais	165,220	170,660	193,310
Mouths of the Rhône	.....	.....	50
Seine	535,580	172,800	270,560
Seine and Marne	10,260	4,460	3,340
Seine and Oise	18,610	15,560	12,490
Lower Seine	64,870	61,830	62,680
Somme	69,330	20,890	61,950
Total	2,119,180	1,399,090	1,686,820
Re-exported.			
In Belgium	.. ...	290	180
	2,119,180	1,399,380	1,687,000

PRUSSIAN AND BAVARIAN COAL.			
Department of Consumption.	1852.	1848.	1847.
	Tons.	Tons.	Tons.
Upper Marne	18,640	12,990	15,760
Manché	49,400	43,000	51,120
Meuse	8,330	11,440	11,480
Moselle	213,370	118,910	141,700
Lower Rhine	18,980	24,110	30,770
Upper Rhine	13,250	6,320	10,970
Vosges	2,290	10,190	10,370
Total	324,260	226,960	272,170
Re-exported			
Into Germany	.....	130	150
	324,260	227,090	272,320

England, it will be seen, supplies thirty-eight departments; Belgium sends her bituminous coal into sixteen departments, among which the

department of Seine figures at more than 500,000 tons, while Loire, as might be expected, with its immense native production, takes into consumption only 19,440 tons; and the Rhenish Provinces supply seven departments.

The Mouths of the Rhône department received from different foreign countries, in the year 1847, 2,880 tons; in 1848, 2,380 tons; and in 1852, 130 tons. English coal encounters that of Loire in 16 departments, and Valenciennes in 9. Belgian coal competes with that of Loire in 8 departments, and that of Valenciennes in 12 departments.

USES TO WHICH THE HOME AND FOREIGN SUPPLIES ARE DEVOTED.

It is interesting to ascertain to what use the coal taken into consumption by France is appropriated. I find that much the larger portion is consumed in manufactures (of all kinds), as is the case in every country. A very considerable quantity is devoted to household purposes; by no means so much, however, in proportion to the general consumption, as in England, for, added to the fact of the warm climate of France, French consumers of both household and manufacturing coal, singular to say, persist in using wood for fuel, sometimes by way of preference, but oftener, no doubt, because it can be purchased on the spot, and apparently at a cheaper rate. To steam purposes on land and sea a very small quantity is at present applied, and the remainder is used in the different mines and quarries.

Taking the years over which all our calculations in this part of the subject extend, I find that in the year 1847, of the 7,648,860 tons consumed, no less than 5,225,000 tons, or two-thirds of the whole, were employed in manufactures; 154,510 tons were applied to domestic purposes; 548,160 tons were used for steam purposes; and the remainder, 330,590 tons, were consumed in the mines and quarries.

During the next year, the year of revolution, the consumption fell, as has been already shown, to 6,095,290 tons. The quantity consumed in the various methods indicated above, of course fell in due proportion. The industrial interests, represented by the manufactures, and household consumption, were the chief sufferers by the disasters of the period; only 4,100,470 tons were absorbed in the manufactures, and less than 1,225,000 tons in domestic uses, and only 492,430 tons were employed for generating steam, and 278,400 tons in the mines and quarries.

By the year 1852 an increase of 300,000 tons only over the consumption of 1847 had been attained, proof significant of the injury inflicted

upon commerce by political disorder. I find that the quantity of coal appropriated during that year (1852), to the different manufactures, was 5,353,830 tons, while in the preceding year it was only 4,889,780 tons and in 1850 not more than 4,709,540 tons. The household consumption in the same year was 1,602,100 tons, and in 1851 1,598,610 tons. For steam purposes, and in the mines and quarries, the figures are respectively 664,820 and 337,770 tons for the former, and 556,920 and 331,520 tons for the latter year.

The annexed table shows the appropriation of the coal in twenty-five of the principal districts, which twenty-five districts, it will be observed by the way, employ full two-thirds of the total quantity consumed.

TABULAR STATEMENT OF THE USES TO WHICH THE HOME AND FOREIGN SUPPLIES ARE APPLIED.

Departments of Consumption.	1852.					1848.					1847.				
	Manufactures of all kinds.	Household purposes.	Steam purposes.	Mines and Quarries.	Total.	Manufactures of all kinds.	Household purposes.	Steam purposes.	Mines and Quarries.	Total.	Manufactures of all kinds.	Household purposes.	Steam purposes.	Mines and Quarries.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Nord	827,240	489,540	84,620	96,530	497,930	846,020	372,870	53,370	95,986	1,368,240	902,300	485,530	52,820	126,720	1,567,370
Loire	398,000	176,560	32,200	101,000	702,700	334,790	151,800	24,380	82,600	592,970	349,030	157,830	24,160	85,850	616,870
Seine	425,480	171,900	65,450	.....	662,830	199,460	85,600	58,950	.....	344,910	311,650	138,500	49,500	.....	499,650
Rhone	294,480	126,450	83,550	5,810	465,290	116 130	112,490	57,770	1,500	285,890	191,900	129,660	75,800	1,520	398,880
Saone and Loire	210,000	85,600	4,850	46,030	346,480	171,780	53 220	2,040	35,350	263,320	217,380	92,180	2,450	41,320	353,330
Straits of Calais	230,470	121,500	13,850	6,070	371,890	187,470	115,840	12,630	2,500	318,440	266,860	114,300	14,000	3,500	398,660
Lower Seine	179,850	49,000	58,700	.....	287,550	139,819	35,000	33,450	.....	208,260	145,700	46,380	41,690	.....	233,770
Gard	194,000	25,900	32,100	3,000	255,000	186,080	31,920	25,650	2 430	246,060	280,640	32,830	27,170	3,000	343,640
Moselle	190,120	15,000	5,540	2,710	213,370	102,060	16,850	.....	.....	118,910	124,270	17,580	.....	.....	141,850
Isere	125,160	68,500	.....	11,880	205,540	81,640	59,440	.....	7,030	148,110	105,600	61,590	.....	9,800	177,050
Allier	178,090	8,940	.....	10,050	197,090	115,929	7,750	.....	7,820	131,490	116,890	7,980	.....	8,690	133,560
Aisne	146,530	28,000	.....	.....	194,533	41,970	7,100	.....	.....	49,070	99,960	18,040	.....	.....	118,000
Mouths of the Rhone	156,040	5,000	49,000	4,500	194,540	113,600	6,320	34,000	.....	153,220	142,540	7,500	43,500	.....	193,540
Aveyron	160,930	10,550	.....	2,050	173,530	117,170	10,070	.....	1,450	128,690	194,770	16,000	.....	2,800	213,570
Oise	95,890	25,000	22,500	.....	141,390	19,000	14,600	9,900	.....	43,500	46,390	19.400	9,600	.....	75,990
Upper Rhine	95,110	12,400	8,500	.....	116,010	29,030	1,640	3,080	.....	33,750	37,040	1,960	2,800	.....	41,800
Somme	50,170	44,500	19,800	.....	114,470	114,400	7,030	6,900	.....	32,379	62,320	51,580	16,070	.....	129,970
Ardeche	67,600	10 800	16,200	.....	94,600	60,480	9,950	50,000	530	127,400	128,800	12,830	56,000	600	198,230
Mayenne	84,400	.....	.....	8,700	93,100	78,150	.....	.....	8,510	86 660	90,373	.....	.....	11,230	101,600
Ardennes	81,268	2,630	.....	800	84,690	52,280	2,460	.....	.....	55,450	96,870	4,000	.....	.....	100,870
Nievre	64,750	5,700	500	5,800	76,750	64,590	6,600	1,200	5,780	78,170	76,380	8,000	400	7,400	92,180
Gironde	52,270	650	20,000	.....	72,920	43,130	670	13,000	.....	56,800	45,690	7,900	13,200	.....	57,680
Calvados	64,050	5,460	1,740	1,600	72,850	44,150	3,020	810	1,980	49,960	67,870	5,000	1,200	2,000	76,070
Herault	52,080	7,910	9,630	670	79,290	84,300	5,700	4,800	590	59,390	47,270	5,100	4,400	500	57,270
Cote d'Or	60,060	7,000	.....	.....	67,000	49,720	4,700	.....	.....	54,420	59,620	3,040	.....	.....	62,600
	4,454,030	1,504.430	528,730	307,200	6,772,340	3,463,830	1,122,640	391,930	253,450	5,085,310	4,208,770	1,444,680	434,760	304,900	6,384,000
Sixty-one other Departments consume	899,800	97,670	136,090	30,570	1,178,180	636,640	2,360	100,500	24,950	1,059,990	1,016,230	100,430	113,400	25,690	1,264,860
Total	5,353,830	1,602,100	664,820	337,770	7,950,520	4,100,470	1,225,000	492,430	278,400	6,095.300	5,225,000	1,545,110	548,160	330,590	7,648,860

Quantities of Coal and other Combustible Material used in the Manufacture of French Iron.

It may be useful to give here some statistics respecting the manufacture of iron in France, especially as it is connected most intimately with the consumption of coal. In the year 1852 there were manufactured in that country 522,643 tons of pig metal, valued at £2,999,867, or £5 15s. per ton; of this quantity 263,340 tons were manufactured with 369,473 tons of charcoal and wood, valued at £871,638, and 259,500 tons with 456,365 tons of coke and coal, valued at £411,988; the value of the portion made with charcoal and wood was £1,708,571, equal to £6 10s. per ton, and that of the portion made with coke and coal £1,290,696, equal to £5 per ton; the average of the two being £5 15s. per ton, which is double the value of English pig metal, probably arising from the expensive character of the combustibles and of the labour employed in preparing the raw material and in its manufacture. In the same year there were manufactured 301,803 tons of malleable iron, the value of which is estimated at £3,651,394, or £12 per ton; 64,601 tons of this quantity employed 147,303 tons of charcoal and wood, valued at £355,546, in its manufacture, while the remainder was manufactured by coke and coal, of which it required 677,214 tons, valued at £450,693; the value of the portion manufactured with charcoal wood was £1,092,046, and that of the remainder £2,559,307.

The total quantity of pig iron produced in France, from about seventy-five blast furnaces, in the year 1852, was thus equal to the present production (1857), of Northumberland, Durham, and Cleveland, where the value of the coke and coal required was less than half the cost of the fuel employed in the same operation in France. It must, however, be observed in making these comparisons, that the cost and value of the produce manufactured with charcoal is much greater in each process than that resulting from the use of coke and coal; and, though little of this description of iron is manufactured in Great Britain, yet large quantities are imported at high rates.

The following table shows, in a condensed, and at the same time comprehensive, form, the figures given above :—

TABULAR STATEMENT OF THE MATERIALS EMPLOYED IN THE PRODUCTION OF IRON IN FRANCE DURING THE YEAR 1852.

MANUFACTURE OF PIG IRON.

Fuel Employed.	Tons.	Aggregate Value of the Fuel.	Average Value of Fuel per Ton.	No. of Tons of Iron Manufactured.	Aggregate Value of the Iron.	Average Value per Ton of the Iron.
		£	£ s. d.		£	£ s. d.
Charcoal	344,552	859,755	2 10 0	*		
Wood	24,921	11,883	0 9 6½	263,340	1,708,571	6 10 0
	369,473	871,638	2 7 2			
Coke	393,945	388,298	0 19 8½	†		
Coal.....	62,411	23,690	0 7 7	259,303	1,290,696	5 0 0
	456,356	411,988	0 18 0½			
Total	825,829	1,283,026		522,643	2,999,267	5 15 0

* The cost of fuel, with charcoal and a little wood, as above, for manufacturing 263,340 tons of pig metal, was £3 6s. 2¼d. per ton.

† The cost of fuel, with coke and a small quantity of coal, for manufacturing 259,303 tons of pig metal, was £1 11s. 9¼d. per ton.

MALLEABLE IRON.

Charcoal	144,870	354,881	2 8 4½	§		
Wood	2,433	1,065	0 8 9	64,601	1,092,046	15 7 0
	147,303	355,946	2 2 4			
Coal.....	30,996	27,448	0 17 8½	‖		
Coke	646,218	423,244	0 13 1	237,202	2,559,307	10 11 2
	677,214	450,692	0 13 3¾			
Total	824,517	806,638		301,803	3,651,353	12 2 0

§ Cost of fuel, with charcoal and a small quantity of wood, for manufacturing 64,601 tons of malleable iron, was £5 10s. 0½d. per ton.

‖ Cost of fuel, with coke and a small quantity of coal, for manufacturing 237,202 tons of malleable iron, was £1 18s. per ton.

Perhaps it may be as well here to give some figures as to the iron trade of other countries, and suppose we take England first. The production of iron in this country, in 1852, was about 3,000,000 tons, and in 1855 it was 3¼ million tons; of this quantity 300,000 tons, more or less, were manufactured in Northumberland, Durham, Cleveland, and Yorkshire.

The production of iron in Prussia is 300,000 tons a year, and, as in

France, a large portion is made with charcoal. If the iron masters employed coal and coke entirely in its manufacture, as much more coal would be employed in that branch of industry. There is every prospect of Prussia becoming an iron making country of high rank. In addition to the various new iron ore concessions, some of them in operation, which I inspected on a recent visit to that country, I also found ninety-one ironstone concessions, extending over several thousand acres in a mountainous country, which have been granted by the Prussian Government to M. Gonot, chief engineer of mining under the Belgian Government, who holds them in readiness, and will, in all probability, commence operations as soon as ever railway transit to and through the locality is completed.

Austria, which possesses abundance of ironstone, produces about 250,000 tons of iron yearly, which is almost entirely made with charcoal.

The United States of America, like France, manufactured, in 1852, about half-a-million tons of iron, and each had increased to 750,000 tons in 1855, which is accounted for by the fact that the price of English iron in this year was full thirty-three per cent. higher than in 1852, and its high price may have stimulated them to develop their own resources.

The iron trade of Belgium, in 1855, influenced, no doubt, by the high price of English iron, was, like that of Prussia, in a flourishing state. The quantity of pig iron manufactured in each country increased considerably in 1856, but not so recently.

Other countries manufactured iron in that year in the following proportions:—

	Tons.
Russia	200,000
Sweden	150,000
Various German States	100,000
Other Countries	300,000

The aggregate quantity of iron manufactured by the whole of these countries falls short of the produce of Great Britain in that year; the total in the former case being 3,000,000 tons, and in the case of Great Britain 3,250,000 tons. Great Britain is the only country that manufactures iron almost entirely from coal and coke, in which manufacture upwards of one-fourth of the coal produced in this country is consumed. A few thousand tons of iron are manufactured from charcoal, the cost of manufacture and market value of which is very similar to that of French iron manufactured by the same process. All the rest is made from coal

and coke, and by this—much the cheaper—means, the production of English coal has increased every year. Whenever the other iron-making countries expend large sums of money, similar to those invested by the coal-owners and ironmasters of this country, in extending their operations in the manufacture of iron and the production of coal, the quantity of coal will, in like manner, be augmented, and their iron become cheaper; in fact, if the iron manufactured by them at the present time were made with coal, fully one-half of the yield of that article would be employed in the process.

The following table is an important addendum to this chapter, as it shows that France is the best customer for foreign coals, and likely to continue so. Comparing the below statement for consumption with the statement at page 84 of the French production, it will be seen that in 1856 the consumption was 12¾ millions, while the production was only 7¾ million tons of coal, making an opening for upwards of five millions of tons yearly of foreign coal. The year 1817 only shows the native production to be one million tons, and that of foreign coal about one quarter of a million tons yearly. The increase at the present time is shown as above.

The consumption in Great Britain, in 1855, when the population was twenty-two millions, gives, after deducting foreign coal exported, 2,863 tons to every 1,000 inhabitants. The population since that period has increased nearly half a million, the production and exportation remaining almost stationary.

The consumption in Belgium in the same year was 1,194 tons to every 1,000 inhabitants; and in France 276 tons.

TABULAR STATEMENT OF THE CONSUMPTION OF COAL IN FRANCE FROM 1802 TO 1856.

Years.	Tons.	Years.	Tons.	Years.	Tons.
1802	935,180	1825	1,994,385	1842	5,203,415
1811	863,694	1826	2,042,262	1843	5,293,508
1812	929,523	1827	2,228,142	1844	5,486,850
1813	858,779	1828	2,352,820	1845	6,343,069
1814	932,599	1829	2,289,877	1846	6,608,884
1815	1,112,194	1830	2,493,944	1847	7,648,870
1816	1,231,958	1831	2,298,211	1848	6,095,210
1817	1,221,909	1832	2,520,159	1849	6,640,548
1818	1,146,162	1833	2,736,662	1850	7,225,270
1819	1,173,817	1834	3,214,405	1851	7,376,830
1820	1,348,122	1835	3,278,218	1852	7,958,520
1821	1,381,839	1836	3,814,955	1853	9,413,297
1822	1,525,261	1839	4,180,753	1854	10,856,785
1823	1,517,362	1840	4,256,711	1855	12,293,686
1824	1,781,509	1841	4,979,892	1856	12,710,820

CHAPTER IV.

Prices of Coal (Native and Foreign) in France.

The price of native coal in France, like that of England, varies according to quality, the geological structure of the district in which it is found, and the consequent ease or difficulty, as the case may be, of preparing it for the market. In some departments in France, for instance, the price is upwards of 16s. per ton at the pit's mouth, while in several others of less importance it is not of more value than 5s.; the average at the place of production, in 1852, being about 8s. 6d. per ton.* This sum, of course, includes the cost of working, rent, materials, and all other incidental charges at the pit top and for underground operations; while in England the best household coal can be put on board ship at different ports at the same price, 8s. 6d., and manufacturing steam coal at 7s., while other sorts, for coke and gas, are as low as 5s. In one or two varieties of our coal,† such as coking and gas and coal

* The French mines and quarries (for in several places the French owners quarry the inferior coal out at the surface) pay two kinds of rent duties to the Government. The one is fixed at a certain sum per hectare, = 11,760 square yards; the other variable, in accordance with prices or profits, but never higher than one-tenth or less than one-twentieth of the net produce.

† The low-priced English coal here alluded to as used in our smithies, coke, gas, and glass works, is of the purest quality, although of a peculiarly tender nature. The very smallest of it, even the dust, being free from pyrites, is used without washing, and when pressed by suitable machinery into the size and shape of bricks, answers all the purposes to which good household, manufacturing, or steam coal may be applied. As an instance of this, I may mention that, a few years ago, an engine fired with this machine-made fuel started with passengers and goods from Darlington Station, and made the trip to Gateshead without stopping, or requiring extra coal or firing—in fact, the stoker never interfered at all with the fire—in the usual time, the distance (*via* Brockley Whins) was 38½ miles, and the consumption was, on the average, less than 21lbs. per mile. The consumption of coke, made from the same coal, is generally at the rate of 26lbs. per mile with express trains, and the engine using it requires firing six times in the course of the journey; consequently there is a difference of 20 per cent. in favour of this compressed fuel, made from small coal, as regards its consumption. Besides, it is more portable and occupies less space, and there is little doubt it could be manufactured to sell at as low a price as good coke, and bring a profit to the maker. I have no doubt that it will continue to be used by marine engines, and gradually come into use for locomotive engines, especially in foreign countries, where wood and coke fuel are dear. Any objection on the ground of smoke might be obviated by properly constructed fire places and careful firing. In this case, with the use of the spare steam from the engine let off into the chimney while working, no smoke was to be seen; and when a small fire place, with an area of less than a square yard, only required to be charged with 7 cwts. of fuel once in 38½ miles, with a heavy train, smoke cannot be at all an objection. Indeed, I have no doubt but the highest authorities, after testing this fuel, and after making careful experiments and comparing this with the heat of other fuels, will have to admit that it is more powerful and better than either the Welsh or what is called the North of England Hartley steam coal—the former being generally very destructive to the engine fire-bars. To corroborate the experiment above alluded to, I may mention that this trial was made in the presence of Mr. R. Fletcher, the engineer for the locomotive department of the North-Eastern Railway, myself, and Mr. Robert Simpson, M.E. and manager to the Stella Coal Company, Ryton, where the small coal manufactured into the fuel was obtained; but, if any doubt remain as to the efficiency of this kind of fuel, I should be happy to superintend another trial of its properties in any form that may be decided upon.

for smithy purposes, the cost of production is only about one-third of the French average. (See page 195 of the second volume of the "Transactions" of this Society.) Very few districts in France produce coal at the pit top at so low a rate as 4s. 6d. per ton, or at 5s. on board ship. One (Vaucluse), in 1852, was as low as 4s. 1d. per ton at the pit top, and there were two or three others in which the price varied from that to 5s.; but the quantity produced was trifling, and in nearly every instance it was taken into consumption on or near these pits. A rather low-priced district is Aveyron, where the price at the pit top is only 5s. 5d. per ton; but there does not appear to be any great demand for the produce, although a navigable river (the Lot) passes the principal basin into the Bay of Biscay, for the total abstraction is under 200,000 tons a-year. The coal of those departments in which the price of extraction is above the average, is also taken into local consumption, and competes, in few instances indeed, with the foreign coal imported.

The tables which follow exhibit, at one view, the variation in the price of coal in various departments of France, the native coal at the pit's mouth and depôt (which depôt, being frequently at a considerable distance from the pit, and with the slow mode of transit, increases the expense), and the price of the foreign coal at the depôt.

TABULAR STATEMENT OF THE COST OF PRODUCTION AND SELLING PRICE OF FRENCH COALS, AND THE MARKET VALUE OF FOREIGN COALS IMPORTED INTO FRANCE, IN THE YEAR 1852.

Department of Consumption.	Quantity Consumed.	Principal Depots.	Whence Obtained.	French Coal.	Belgian Coal.	English Coal.	Price at Pit.	Price at Depots.
	Tons.			Tons.	Tons.	Tons.	Per Ton.	Per Ton.
							£ s. d.	£ s. d.
Nord	1,376,970	Lille	Valenciennes	541,500	.....	.....	0 8 5	0 12 3
		Dunkirk	Belgium	.....	827,670	.....	.....	0 11 9
		Gravelines	England	.....	.....	7,800	.....	0 10 11
Straits of Calais	343,050	Arras	Valenciennes	140,700	.....	.....	0 9 6	1 1 4
		Boulogne	Hardinghen	18,600	.....	.....	0 12 11	0 15 11
		Calais	Frejus	150	.....	.....	0 14 6	0 16 9
		St. Omer	Belgium	.....	146,970	.....	.....	0 19 4
			England	.....	.....	36,630	.....	1 3 5
Somme	140,350	Amiens	Valenciennes	51,730	.....	.....	0 9 6	0 17 5
		Abbeville	Belgium	.....	90,210	.....	.....	0 15 9
			England	.....	.....	8,610	.....	1 3 6
Lower Seine	267,720	Rouen	Valenciennes	2,100	.....	.....	0 9 6	1 3 1
		Havre	England	.....	.....	198,810	.....	1 2 1
		Dieppe	Belgium	.....	66,810	.....	.....	1 5 6
Eure	38,340	Evreux	Valenciennes	13,980	.....	.....	0 9 6	1 5 6
			Belgium	.....	16,420	.....	.....	1 7 4
			England	.....	.....	7,890	.....	1 7 2

TABULAR STATEMENT OF THE COST OF PRODUCTION, &c.—CONTINUED.

Department of Consumption.	Quantity Consumed.	Principal Depots.	Whence Obtained.	French Coal.	Belgian Coal.	English Coal.	Price at Pit.	Price at Depot.
	Tons.			Tons.	Tons.	Tons.	Per Ton.	Per Ton.
							£ s. d.	£ s. d.
Seine	653,060	Paris	Valenciennes	123,080	.....	.....	0 9 6	1 5 1
			Commentry	14,860	.....	.....	0 5 11	1 5 1
			Loire	12,280	.....	.....	0 7 4	1 13 5
			Decize	1,770	.....	.....	0 9 5	1 4 3
			Creusot and Blanzy	390	.....	.....	0 6 9	1 3 11
			Belgium	.....	501,220	.....	.....	1 4 5
			England	.....	.....	360	.....	1 5 2
Eure and Loire	7,420	Chartres	Valenciennes	3,690	.....	.....	0 9 6	1 13 7
			Loire	2,100	.....	.....	0 7 4	2 3 5
			Belgium	.....	1,140	.....	.....	1 14 7
			England	.....	.....	490	.....	1 15 6
Calvados	64,720	Caen, Honfleur	Littry	27,970	.....	.....	0 12 4	0 14 4
			Valenciennes	980	.....	.....	0 9 6	1 3 0
			Hardinghen	690	.....	.....	0 12 11	1 3 0
			England	.....	.....	35,000	.....	1 4 10
Manche	40,290	Cherbourg, Carentan, Coutence	Valenciennes	6,370	.....	.....	0 9 6	1 0 11
			Littry	200	.....	.....	0 12 4	0 16 8
			England	.....	.....	33,720	.....	1 0 7
			.....	.....	.....	.....	.....	
		Avranche	.....	.....	.....	.....	.....	
Sarthe	32,100	Le Mans	Le Maine	20,470	.....	.....	0 14 3	1 0 6
			Loire	1,430	.....	.....	0 7 4	2 2 2
			Brassac	1,080	.....	.....	0 7 7	2 0 11
			England	.....	.....	3,120	.....	1 10 4

TABULAR STATEMENT OF THE COST OF PRODUCTION, &c.—CONTINUED.

Department of Consumption.	Quantity Consumed.	Principal Depots.	Whence Obtained.	French Coal.	Belgian Coal.	English Coal.	Price at Pit.	Price at Depot.
	Tons.			Tons.	Tons.	Tons.	Per Ton.	Per Ton.
							£ s. d.	£ s. d.
Eastern Pyrenées ..	4,070	Perpignan ..... Port Vendee	St. Gervais	1,200	.....	.....	0 8 3	1 11 3
			Durbant Sègure	950	.....	.....	0 11 4	0 14 9
			Estravan	880	.....	.....	0 4 2	0 4 2
			Alais	220	.....	.....	0 5 5	1 9 11
			Loire	180	.....	.....	0 7 3	1 12 0
			England	.....	.....	720	.....	1 13 7
Upper Garonne	26,390	Toulouse	Carmeaux	11,820	.....	.....	0 13 9	1 6 8
			Loire	6,600	.....	.....	0 7 3	1 11 8
			Alais	4,530	.....	.....	0 5 5	1 8 2
			St. Gervais	1,000	.....	.....	0 8 2	1 5 0
			England	.....	.....	2,440	.....	1 8 2
Herault	57,390	Montpellier	St. Gervais	23,030	.....	.....	0 8 2	1 5 10
			Alais	17,370	.....	.....	0 5 5	1 9 7
			Rougan	6,310	.....	.....	0 7 10	1 3 11
			Lacanmette	3,890	.....	.....	0 3 1	0 14 0
			Loire	3,660	.....	.....	0 7 3	1 7 6
			Aubin	500	.....	.....	0 5 1	1 4 8
			England	.....	.....	2,630	.....	1 8 2
Mouths of the Rhone	179,350	Marseilles	Aix	91,700	.....	.....	0 10 0	0 16 4
			Alais	49,000	.....	.....	0 5 5	1 2 4
			Loire	18,980	.....	.....	0 7 3	1 4 8
			Frejus	500	.....	.....	0 8 1	1 2 6
			England	.....	.....	19,170	.....	1 8 2

TABULAR STATEMENT OF THE COST OF PRODUCTION, &c.—CONTINUED.

Department of Consumption.	Quantity Consumed.	Principal Depots.	Whence Obtained.	French Coal.	Belgian Coal.	English Coal.	Price at Pit.	Price at Depot.
	Tons.			Tons.	Tons.	Tons.	Per Ton.	Per Ton.
							£ s. d.	£ s. d.
Vendèe	15,620	Napoleon Vendèe..	Vouvant & Chantonay	14,450	.....	.....	0 11 1	0 14 8
			England	.....	.....	1,170	.....	1 5 5
Lower Charente....	17,280	Rochelle	Vouvant	.....	.....	.....	0 11 1	1 3 9
		Rochefort	England	.....	.....	14,980	.....	1 11 0
Charente	9,580	Angoulème	England	.....	.....	9,580	.....	1 10 6
Indre and Loire.....	30,561	Tours	Loire	5,770	.....	.....	0 7 4	1 11 11
			Commentry	3,260	.....	.....	0 5 10	1 9 10
			Creusot and Blanzy..	1,260	.....	.....	0 7 5	1 11 3
			Brassac	1,190	.....	.....	0 7 7	1 10 7
			Lower Loire	1,020	.....	.....	0 8 4	1 0 0
			Decize	720	.....	.....	0 9 4	1 8 5
			England	.....	.....	17,640	.....	1 3 10
Gironde	57,980	Bordeaux	England	.....	.....	57,980	.....	1 0 10
Dordogne	8,010	Perigeux	Terrasson.....	2,380	.....	.....	0 18 4	0 19 7
			Meimac	50	.....	.....	1 3 3	1 5 0
			England	.....	.....	5,580	.....	1 4 1
Landes.....	....	Mont de Morson..	England	.....	.....	2,050	.....	1 8 10
		Bayonne						
Lower Pyrenèes	2,120	Pau	England	.....	.....	2,120	.....	1 3 6

TABULAR STATEMENT OF THE COST OF PRODUCTION, &c.—CONTINUED.

Department of Consumption.	Quantity Consumed.	Principal Depots.	Whence Obtained.	French Coal.	Belgian Coal.	English Coal.	Price at Pit.	Price at Depot.
	Tons.			Tons.	Tons.	Tons.	Per Ton.	Per Ton.
							£ s. d.	£ s. d.
Eastern Pyrenèes ..	4,070	Perpignan ..... Port Vendee	St. Gervais	1,200	.....	.....	0 8 3	1 11 3
			Durbant Sègure	950	.....	.....	0 11 4	0 14 9
			Estravan	880	.....	.....	0 4 2	0 4 2
			Alais	220	.....	.....	0 5 5	1 9 11
			Loire	180	.....	.....	0 7 3	1 12 0
			England	.....	.....	720	.....	1 13 7
Upper Garonne	26,390	Toulouse	Carmeaux	11,820	.....	.....	0 13 9	1 6 8
			Loire	6,600	.....	.....	0 7 3	1 11 8
			Alais	4,530	.....	.....	0 5 5	1 8 2
			St. Gervais	1,000	.....	.....	0 8 2	1 5 0
			England	.....	.....	2,440	.....	1 8 2
Herault	57,390	Montpellier	St. Gervais	23,030	.....	.....	0 8 2	1 5 10
			Alais	17,370	.....	.....	0 5 5	1 9 7
			Rougan	6,310	.....	.....	0 7 10	1 3 11
			Lacanmette	3,890	.....	.....	0 3 1	0 14 0
			Loire	3,660	.....	.....	0 7 3	1 7 6
			Aubin	500	.....	.....	0 5 1	1 4 8
			England	.....	.....	2,630	.....	1 8 2
Mouths of the Rhone	179,350	Marseilles	Aix	91,700	.....	.....	0 10 0	0 16 4
			Alais	49,000	.....	.....	0 5 5	1 2 4
			Loire	18,980	.....	.....	0 7 3	1 4 8
			Frejus	500	.....	.....	0 8 1	1 2 6
			England	.....	.....	19,170	.....	1 8 2

TABULAR STATEMENT OF THE COST OF PRODUCTION, &c.—CONCLUDED.

Department of Consumption.	Quantity Consumed.	Principal Depots.	Whence Obtained.	French Coal.	Belgian Coal.	English Coal.	Price at Pit.	Price at Depot.
	Tons.			Tons.	Tons.	Tons.	Per Ton.	Per Ton.
							£ s. d.	£ s. d.
Var	42,370	Toulon	Alais	17,000	.....	.....	0 5 5	1 5 0
			Loire	13,000	.....	.....	0 7 3	1 6 3
			Aix	7,000	.....	.....	0 10 0	0 12 6
		Dragnignan	La Cardière	1,650	.....	.....	0 10 0	0 12 6
			Frejus	300	.....	.....	0 8 1	0 13 4
			England	.....	.....	2,920	.....	1 6 8
Corsica	48,700	Ajaccio	England	.....	.....	48,700	.....	1 9 2
Lot and Garonne	23,600	Flagen	Carmeaux	1,180	.....	.....	0 13 9	1 13 4
			Aubin	500	.....	.....	0 5 1	1 9 2
			England	.....	.....	680	.....	1 15 10
Orne	14,880	Alençon	Loire	2,200	.....	.....	0 7 3	1 18 4
			England	.....	.....	12,680	.....	2 0 1
Two Sevrès	6,900	Nort	Vouvant	6,120	.....	.....	0 11 1	0 19 8
			England	.....	.....	780	.....	1 7 11
Vienne	4,610	Poitiers	Vouvant	1,380	.....	.....	0 11 1	1 11 6
			Loire	930	.....	.....	0 7 3	2 0 10
			Lower Loire	920	.....	.....	0 15 1	1 15 11
			Creusot and Blanzy	90	.....	.....	0 15 9	1 8 9
			England	.....	.....	1,290	.....	2 1 8
Upper Vienne	3,000	Limoges	Hun	1,410	.....	.....	0 10 1	1 9 0
			Meimac	450	.....	.....	1 2 9	2 10 0
			Commentry	360	.....	.....	0 5 10	1 15 0
			England	.....	.....	730	.....	1 17 2

CONCLUDING OBSERVATIONS.

In bringing this paper to a close, I need scarcely mention what will have been observed in reading these pages, that, whilst France is every year increasing its consumption (more rapidly than any other country, except England), and, necessarily, its demand for coal in a larger proportion than its native supply, its reliance upon foreign coal increases in an equal ratio. The consumers of fuel in that country are beginning to find that wood, for which they have heretofore, in a great many instances, exhibited a preference—partly, no doubt, owing to the difficulty (as is shown in the preceding tables) of procuring good coal at a reasonable price—is both expensive and cumbersome, and that coal alone is universal in its application to their wants and requirements. And they are now beginning to find, too, that of all coals brought into the market the English are decidedly the best, and that their employment of it in the various manufactures and in household consumption is as yet limited only by the heavy restrictive duties imposed upon it. Once place English coal upon a footing with that of Belgium, or, rather, which is the only fair course, remove the restriction altogether, as well from the Belgian and the Prussian as the English, set them all upon an equality in this respect, and the figures which indicate the respective exportation into France from those countries, will soon be altered. England would, doubtless, take the lead, even if the supplies from Belgium remained in *statu quo*. That this result would follow in a few years hardly requires to be formally shown, it would be difficult, I should imagine, to find any person at all acquainted with the subject to dispute the fact. For, independent of the superiority of the article, the freights of vessels from our own shores are getting every year so low, and the distance between Great Britain and the coast of France is so short, that we shall always be able to have the advantage over either Belgian or even French coal in the sea-port towns; besides which the owners of vessels trading between England and France find that coal answers the purpose of ballast when other goods cannot be obtained at remunerative freights. The river Seine, too, which is the key to Paris for the sea-borne coal trade, has now a depth of eight feet of water at least, and is navigable for screw steamers of 500 tons burthen, while, only a few years ago, in some places it was not deeper than three feet. Improvements are going on which will probably make it still deeper, and it will then be navigable by vessels of much heavier draught. Then, again, if we take into considera-

tion that the French coal-fields are, generally, very inferior, have hitherto lacked many of the mechanical and other advantages which we possess, and, in opening, require a large amount of capital,—the best seams being thin and deep, and hence doubling the cost of working above the average of English mines,—we shall easily appreciate the manner in which the French coal-owners would compete with us in a fair field; nor is it difficult to imagine how the cheapening of the cost, and acceleration of speed of transit, added to our easier method of extracting coal of a quality in every way superior, would affect the other foreign exporters.

If it were not thought too wide a digression, I might here allude to the various means for facilitating the exportation of English coal to France, projected and carried out, though in different ways, by various parties interested. First, may be mentioned the scheme of the Anglo-Gallic Steam Navigation Company, (composed almost entirely of English capitalists,) who proposed to construct vessels with light draught of water, to take coals up the Seine to Paris. It will be in the recollection of all the members present, that the first vessel set afloat by this Company, stranded, near Fecamp, on the French coast, in a violent gale of wind; but misfortunes of that kind cannot always be provided against, and another vessel may be more successful. Then there are the vessels built on a large scale, by some of the coal proprietors, among which may be mentioned the *Rouen*, the property of Messrs. Hugh Taylor & Co., of London, which has a capacity of 800 tons, with only eight feet draught, which has been engaged in conveying coals from the Tyne and Wear to the town whose name she bears; whilst another large vessel, the *William Cory*, belonging to the same Company, capable of carrying 1,700 tons of coal, launched a short time ago, will add materially to the cheapening of transit. A vessel belonging to this Company made as many as forty-six voyages from the northern coast to London in one year; and sailing vessels have been carrying coal the same distance at as low as 4s. 9d. to 6s. per ton. The distance from the Tyne and Wear to the Thames and back is about equal to that between the same rivers and the Seine and other ports on the French coast, so that it is easy to see how rapidly, and to what large extent, English coals can be supplied to France.*

Already those of the French who are acquainted with its properties entertain a marked preference for English coal, nor would it be difficult to point out districts in the interior of France in which the owners have employed it in working the steam engines which bring their coal from

* The following is a table of the comparative number and tonnage of registered sailing and steam vessels (exclusive of river steamers) of the United Kingdom, employed

these mines to the surface. Seeing, then, that our coal is so superior to that of either France or Belgium, and that it would be very largely taken into consumption were it not for the taxes with which it is burdened, it will be well worth our while to see what are these duties for the sake of which the French Government deprive so many of its manufacturers and domestic consumers of so useful and necessary an article.

As they stand at present, the duties are about 25 per cent. on the first cost of Belgian coals, and 50 per cent. on the cost, on board of ship, of English coals. They are, therefore, at present, cent. per cent. in favour of the Belgian exporters, though several reductions of the monopoly in their favour have taken place, as already shown. Belgium pays to the Government an uniform rate of 1 franc 80 cents., (1s. 6d.,) upon every ton of coal imported into France from that country, whilst English coal pays into the treasury 3 francs 60 cents., or 3s. per ton on all coals delivered north of Sables d'Olonne, a town on the west coast of France. Three-fourths of the most populous territory in that country, therefore, labour under a disadvantage which is not shared by their more fortunate neighbours in the south (*See Map.*) The coals delivered south of this place are charged only 1s. 6d. per ton, the same rate as Belgium. Independent of these duties, an octroi of 7 francs 20 cents. per French ton of 1,000

in the home and foreign trade, and the number of men therein, exclusive of captains:—

	No.	Tons.	Men employed.
Steamers in 1850	426	104,680	8,700
Ditto in 1857	899	381,363	24,953
Increase	473	276,683	16,253
Increase per cent. over the last ten years	118	265	187
Sailing vessels in 1850	17,460	3,032,532	142,730
Ditto in 1857	18,429	3,880,119	151,434
Increase	963	797,567	8,704
Increase per cent. in ten years	5½ per cent.	25¼ per cent.	6 per cent.

It, however, needs no figures to show that the trade in sailing vessels is falling off, while steam vessels are increasing rapidly in public favour. The experience of every member of this society tends to illustrate the fact. The culminating point of the demand for vessels of this latter class seems to have been attained by the successful launch of the Great Eastern; but this vessel, there is little doubt, will not long remain the wonder of the world. British skill and enterprise will produce others equal in size and power, and effect the revolution in the shipping trade which she has commenced. River steamers of larger dimensions are taking the places of the old collier brigs and barges everywhere, and are being constructed, in great numbers, of double the strength and only half the weight of their predecessors, to carry heavier loads with less draught of water—an improvement of the utmost importance to the coal trade, as well as to the mercantile marine and navy. To further illustrate the improvements that have taken place in steamers during the last ten years or so, it may be stated that the steamers crossing the Atlantic go so much quicker that they save two days' coaling each way, or one-sixth less fuel per trip. Should the Great Eastern, which has such immense sailing powers, independent of steam, cross in one-third less time, she would, in all probability, save twenty-five per cent. in fuel, and it might be still more favourable according to her tonnage.

kilogrammes, or about 6s. per English ton (more than the average selling price of coal per ton at almost any shipping port in England) is levied in all cases by the municipal authorities, by whom it is applied to purposes of local improvement. About 25 years ago, the Corporation of of London levied a similar tax upon all the sea-borne coal entering the Thames; but that impost having been found for many years to injure the trade, and to be generally impolitic, was abolished by Government, with the concurrence of the Corporation and the public at large, in 1831. Since that time the London coal trade has doubled itself, and, there is no doubt, similar circumstances would produce a similar result in France.

The monopoly in favour of Belgium during the reign of Louis Philippe resulted from two paramount causes:—the dynastic alliance of the reigning powers, and the influence of the monied interest. The former gave Belgium, by treaty, the preferential position with respect to duties, and the latter engaged the principal bankers and nearly all the monied men in the French capital by its investments in the Belgian mines and the privileged canals communicating with Paris. In the present reign, one of these motives for unduly fostering a limited market to the prejudice of the general industry of France has been superseded, and I fail to see any good reason why an impartial administration should not at once bring all sources to a just level. These taxes surely cannot be imposed for the sake of the paltry revenue they yield to the national exchequer, for the utmost sum realized from that source during the last 20 years has not exceeded £70,000 a-year, and out of this deduct the cost of protection, collection, &c., and probably not more than £60,000 per annum has found its way into the coffers of the Government. The amount realized by the imposts on Belgian and Prussian coal has been about double the sum above-named per year, from which deduct expenses, and the probable amount actually realized will not exceed £120,000 a-year. In 1856 the sum realized by taxes upon Belgian and Prussian coal imported was £229,000, and that realized upon English £133,000, so that it is to obtain so small a contribution to the public treasury as £360,000 sterling, (it will be much less after deducting the expense of collecting it), that the French manufacturers are crippled, their progress obstructed, and the great bulk of a population, numbering thirty-six millions, are denied the comforts and advantages of good and cheap coals. To show that my figures truly represent the case, I give the exact amount received for duties on imported coal and coke for each year since 1851:—

Year.	Produce of Duties.
1851	£249,223
1852	306,902
1853	285,256
1854	248,171
1855	333,550
1856	362,878

The amount for 1857 will not materially differ from that for 1856.

If the French Government were to abolish these imposts altogether, and levy the octroi of 7 francs 20 cents. only; the extra quantities of English coal alone which would be taken to Paris, &c., would produce more revenue applicable to the embellishment of that and other cities than ever was obtained from it under the present or any previous system. The octroi upon one million tons of coals from this country additional to the quantity we now send thither (and this quantity would, in all probability, soon be realized), would produce £300,000—upwards of four times as much as is now received upon coals entering Paris; and the result, as regards Belgium, would be beneficial in a still greater proportion; so that, if the local authorities should offer to pay the Government duty on this extra importation at half the rate now charged, 3s. per ton, they would have, upon this assumed quantity, a surplus beyond what they now receive of 4,000,000 francs, or £160,000 clear gain, besides obtaining at a cheap rate (3f., or 2s. 6d. per ton, independent of the great reduction that would take place in carriage,) the best coals for household and manufacturing purposes. It is strange that, with the example of England, America, and Belgium before her, (for the importation of coals into Belgium is unrestricted, and many English coals on that account go through Belgium into France to avoid paying one-half of the duty imposed upon English coal,) France should still persist in withholding the benefits of free trade in coal from her manufacturers and citizens. In this country, the plan was tried for a number of years, duties being levied both upon the home consumption and the foreign exportation. Whilst the system existed, our consumption increased in a steady ratio only; but as soon as it was abolished, many millions sterling of extra capital was embarked, and a new impulse was given to the trade, insomuch that the figures representing the annual yield which, in 1830, stood at about 32,000,000 tons, is now 66,500,000 tons—more than double. In the year 1840, the system was renewed, so far as it related to coals exported, but it did not answer, and was quickly abandoned. Since that time, the capital which has been invested

in the trade has more than doubled itself, until the total has reached £90,000,000 sterling, as may be seen on reference to pages 68 to 72 of the fourth volume of the "Transactions" of this Society.

Then, again, an additional argument in favour of this course is furnished by the fact that to America, a country 3,000 miles distant, and containing upwards of 150,000 square miles of coal district, we send about one-fourth as much coal as we do to France, only 300 miles away. For a long time coals have been shipped from ports on the north-east coast to various parts of America, at 15s. per ton freight, and the same coals have even been sent to London and re-shipped, in the Thames, for America, at as low freight as 10s. per ton. What, therefore, has been done in the case of a long voyage, can surely be done with much greater ease, and at a very much cheaper rate, when the distance is short. If the duties were less in favour of Belgium, and competition on fair and equal terms permitted, we could, in all probability, undersell every other country taking coals to the French market. The distance is not great, the coaling would require much less time and expenditure than in the case of a voyage to America, for instance, and the cost of transit would be much reduced by the steam vessels putting in on the return voyage, say at Whitby or Redcar, or some other place, and bringing a cargo of ironstone or other heavy goods at low freights, on to the Tyne, Wear, Derwent, or Tees, where coal, and limestone, and all things necessary for the manufacture of iron, &c., can be had on the spot, and where about 100 blast furnaces are in active operation. The vessels beforementioned could ship their cargo, make the voyage, and discharge at the port of destination, with comparative ease, in nine or ten days, and thus supply a large quantity of our superior coals to the French consumer much cheaper than they have hitherto supplied themselves.

And if these facts were not a sufficient inducement, those which appear upon the face of their own records ought to satisfy them that, in proportion as obstacles to trade are removed, trade flourishes and becomes great. In the year 1834,* the then Government of France lowered the duties of both English and Belgian coals, and the importation rose from 772,000 tons in the next year to 1,290,000 tons; and in 1856, twenty-two years after, fifteen times as many English and four times as many Belgian coals were taken into consumption per year. I am sure I need not add another line, except to repeat the hope that, in no long time, we may congratulate the present Government of France upon having granted to consumers the privilege of purchasing the best

* The Native production at this time was only one-third what it is now.

coals in their respective localities free from destructive and injurious duties, and upon having by this means conferred a boon upon all classes of coal consumers in that large empire.

APPENDIX.

PORTS OF FRANCE AND CORSICA.

Abbeville.
Agde (Mediterranean).
Aiguillon.
Ajaccio (Corsica).
Ambleteuse.
Antibes (Mediterranean).
Andierne.
Auray.
Anthie.

Baudol (Mediterranean).
Barfleur.
Basse Indre.
Bastia (Corsica).
Bayonne.
Beauvoir.
Belle Isle
Blaze.
Bordeaux.
Boulogne.
Bourgdault.
Bourgueuf.
Brest.

Caen.
Calais.
Calve (Corsica).
Cameret.
Cancale.
Cannes (Mediterranean).
Carentan.
Cassis (Mediterranean).
Caudebec.
Cette (Mediterranean).
Charente.
Chateaulin.
Cherbourg.
Crotat, La (Mediterranean).
Concarnean.
Conquet.
Croisie.
Crotoy, La.

D'Aix, Isle.
De Baton, Isle.
Devise.
Dialette.
Dieppe.
Dinan.
D'Omonville.
Douarnenez.
Ducler.
Dunkirk.

Estaples or Etaples.
Eu.

Fecamp.
Flotte, La.
Fos (Mediterranean).

Granville.
Gravelines.
Guildo.

Harfleur.
Havre de Grace.
Honfleur.

Indredt.
Isigny.
Isle de Rhe.

La Flotte (Isle de Rhe).
La Hogue.
Landernean.
Lannion.
Larita (Mediterranean).
La Rochelle.
Laune (Portugal).
Le Crotoy.
Le Leque.
Le Havre.
Le Pelleren.
Les Sables.
Lezardieux.
Libourne.
Lillebonne.
Locmariaquer.
L'Orient.
Luc.
Lucon.

Malo, St.
Marans.
Marseilles.
Morlaix.

Nantes.
Noirmontiers.

Oleron or Oloron.

Paimbœuf
Paimpol.
Pelerin, Le.

Perros.
Pont l'Abbe.
Pontrieux.
Pornic.
Porsal.
Port En Bessin.
Port Laune.
Port Louis.
Port Vendres (Mediter.)

Quillebœuf.
Quimper.

Redon.
Regneville.
Rhe, Isle de.
Riberac.
Rochebernard.
Rochelle, La.
Rochefort.
Roscof.
Rouen.

Sables D'Olonne.
St. Brieux.
St. Germain.
St. Gilles.
St. Jean de Luz.
St. Malo.
St. Martin.
St. Michael.
St. Nazaire.
St. Servan.
St. Tropez (Mediterranean).
St. Valery en Caux.
St. Valery sur Somme.
Saintes.
Salins.
Sarzeau.
Saujon.

Teste.
Toulanbery.
Toulon (Mediterranean).
Treguir.
Tremblade, La.
Treport.
Trinite.
Trouville.

Valery or St. Valery.
Vannes.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, MAY 13, 1858, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

The Secretary having read the minutes of the Council, the following gentlemen were elected members of the Institute:—Mr. James Curry, Cassop Colliery, county of Durham; Mr. William Hall, Page Bank Colliery, county of Durham; Mr. W. W. Bailey, Kilbourne, near Derby.

The paper of Mons. F. Laurent, on "The Lemielle System of Ventilation," was read, and ordered to be printed.

The PRESIDENT then called attention to the paper intended for discussion, viz., "The Lundhill Colliery Explosion." But before proceeding to the discussion, he would read the last paragraph in the paper, as it contained matter which might form the basis of the discussion. The paragraph is as follows:—

"Having thus, I trust, given in such detail all the circumstances arising out of this lamentable and distressing accident, and having given, likewise in detail, all the means taken to recover the bodies and restore the ventilation of the mine, and having also given all the data which presented themselves on the re-opening of the pit which could in any way throw any light upon the cause or causes which led to the fatal accident, or which could in any way elicit practical data or experience which may be the means of preventing the recurrence of such a calamity; I must, therefore, leave to the discussion of this paper by the members of the Institute, the development and practical bearing of such facts, towards the elucidation and discovery of the causes which led to such accident."

This paragraph, said the President, would, he thought, point out to them the best course, probably, to pursue in the discussion, with a view

of arriving at the cause of such accident. At the inquest he (the President) expressed an opinion as to what appeared to him to be the cause of the explosion, and subsequent reflection had not induced him to alter such opinion, neither could he add much to the observations then made. He might, in fact, say that it was still his opinion that the causes he then assigned, and the circumstances therein detailed, were substantially correct. He might at the inquest have made more detailed observations, but being then giving evidence before a jury, he was obliged to make as concise a statement as possible. He had since added to that statement a few additional particulars, which, together with the original observations, he would now read, and then afterwards the discussion might proceed. He thought the discussion might be divided into three heads, viz.:—1st. The system of working; 2nd. The system of ventilation; and 3rd. The distribution of the air, which would comprise the questions of the doors and regulators, and other artificial means used in such distribution. He would now read the observations which he made at the inquest, and the additional particulars to which he had alluded:—

I will now explain the system which has been pursued at the Lundhill Colliery in working and ventilating that colliery. First of all, it is necessary to state that the Barnsley bed of coal, which is the bed they have been working at Lundhill Colliery, contains a quantity of inflammable gas at the depth from the surface at which the coal was then worked. Speaking generally of this district, near the surface, the gas of this seam, as well as of most seams, escapes to the surface, and it is, consequently, found, that at a certain depth there is little or no gas evolved. It has been the system in the Barnsley district to work in a particular manner by what is called "board-gates and benks," that, I think, is the local term, or "benks and board-gates." The benks being the part which is excavated, and of a considerable width, and in this case ultimately sixty yards in width, out of which the entire coal is excavated, and the roof allowed to fall into the space excavated. So long as the seam or bed of coal produces no gas, this may be called a safe mode of working, and of using naked lights; but if the coal produces gas, then, the gas being lighter than the atmospheric air, fills the space above the falls in the benks, and so produces what may be termed magazines of gas. In this case there was gas produced from the seam. I presume it is only necessary for me to state so, because all the evidence has gone to prove this, and therefore, I consider, we must come to the conclusion

that there was more or less gas in the whole of the benks in this colliery. In such cases I consider it quite improper to use candles, and, in the particular mode in which this pit has been worked, it is more than ordinarily dangerous to do so. In the mode of working by benks and board-gates at some collieries, the entire width of the benk is taken at one time, all the men being employed at the extreme end or face of the benk; but in this case the coal has been worked by a system called "following-up benks," namely, taking away about one-third of the entire width of the benk at first, and working away the remaining portions of the coal on each side of such first working, at some distance from the face, and at the same time that the workmen are taking the coal away at the extreme end or face of the benk. This involves the use of naked lights, where candles are used on the sides as well as on the ends or face of the benks, so that there are three sides of the benks surrounded with lights. In this case the lights used were candles, so that if any gas, by falls or otherwise, was forced out of these benks, or out of the goaves of such benks, it was liable to be ignited by the naked lights, either in the face or on the sides of the benks. In my opinion this has been the proximate cause of the explosion. I shall now proceed to explain the system of ventilation of the mine, of the mode in which such ventilation was conducted through the mine, and then I shall have some remarks to make upon the practice adopted in the use of candles and lamps at this colliery, and also with some observations in reference to the discipline and management of the colliery. I shall afterwards state the result of the examination of my colleagues and myself with reference to ascertaining in what part of the pit the explosion occurred, and so endeavour, if possible, to point out the immediate cause of the explosion. First of all then, with reference to the ventilation. There is a downcast shaft and an upcast shaft. The ventilation is produced by a furnace. We had no opportunity of testing the quantity of air produced by the furnace, previously to, and at the time of the explosion, but our enquiries led us to the conclusion that there were somewhere between 50,000 and 60,000 cubic feet per minute, which, if judiciously conducted around the workings, was quite sufficient to ventilate the colliery, and render it safe if properly lighted; that is, if lamps had been used, the air was sufficient to render the pit quite safe. The air was split into two divisions, one current traversing or being conveyed round the southern division of the pit, and the other current round the northern division, meeting together in the No. 1 board-gate, immediately to the west of the upcast shaft, as

shown by the darts on the plan. I quite approve of this division of the air, but I do not think that it has been carried sufficiently far, I think more divisions would have been advisable. Then I think the distribution of the air into the several board-gates and benks not the most judicious, but in some degree very objectionable. In the first place, there are, I believe, about fifty-three doors in the pit; no distribution of air in a pit of the extent of this ought to have anything like that number of doors. The number of doors is very objectionable, being liable to be neglected by the trappers, or boys who open them. It is usual, likewise, in all the main roads, that double doors, namely, two doors instead of one, should be used; so that when one is open the other remains shut, and the current of air is consequently kept continuous; and two doors are, of course, less liable to be neglected than one. There are eight board-gates or main roads in this pit, in all of which double doors ought to have been used, whereas single doors only have been used. The effect of one of these doors being open would be that the current, instead of being carried round the workings beyond, would pass through the doorway thus left open, and so lay dormant, or interrupt the ventilation of all the workings beyond such door. Now, the door nearest to the pit being neglected, would lay dormant on the south side, Nos. 1, 2, 3, 4, and 5 benks, and the south levels, and Nos. 2, 3, 4, and 5 board-gates. The neglect of the first door on the northern side would lay dormant Nos. 2, 3, and 4 benks and Nos, 1, 2, 3, and 4 board-gates, and the north levels. Then the doors on each side, in the No. 2 board-gates, would lay dormant the benks beyond them, and so with Nos. 3 and 4 doors, they would lay dormant the workings beyond those doors. The principle of making the ventilation dependent on doors is, therefore, exceedingly objectionable. Then I find that candles or naked lights may be said, practically, to have been entirely used in the pit, for, although there has been safety-lamps used, I find the practice has been, that orders have been given to the packers and some other persons in the pit, to use lamps only when they considered their use necessary. A discretion was thus given to those men, only to have the tops on when they thought it was necessary. I think any system of using naked lights around goaves or benks bad, but more especially in this case, where they are used on three sides of the benks, they were extremely dangerous. This is, I believe, the third accident in this district which I have been called upon to examine into, and all those three explosions have been caused by the use of naked lights, under very nearly circumstances to those of the present, and

would have been avoided had safety-lamps been used. I stated, on the two former occasions, that it was extremely dangerous and improper to use naked lights in the vicinity of such goaves. I stated this also, very strongly, in my evidence before Committees of both Houses of Parliament, pointing out as decidedly as I could, the danger of so doing. I mention these circumstances on this occasion, because I do hope that these terrible examples, will be the means of inducing a more safe mode of working the coal, and of lighting the mines in this district. Then as regards the discipline practised in this colliery, it seems to have been extremely lax. It is not safe, generally, to give discretionary powers, where danger is apprehended, to numbers of people, to use lamps or candles as they may deem it advisable; decided orders should be given, one way or the other. The boys who open and shut the doors, which I have previously alluded to, seem likewise to have been allowed to leave their doors at particular meal times in the day; in the Northumberland and Durham District we fine the boys if they leave the doors at any time.

I will now explain the state in which we found the pit on our examination. We first travelled round the southern division of the pit. We endeavoured to ascertain in what direction the explosion of gas had passed around this division of the pit, by the direction in which the doors and stoppings of the pit were blown. I have marked upon the plan (published in the V. volume of the "Transactions" of the Institute), the direction wherever that could be ascertained, and my colleagues and myself were of opinion that the blast had proceeded from the north and west of the pit in the direction of and round the south. The darts shew the direction in which the stoppings and doors were blown, and consequently the direction in which the blast proceeded. The blast, it appears, had proceeded towards and around the south portion of the mine from the northern and western parts of the pit. It had apparently proceeded up the Nos. 2, 3, 4, and 5 board-gates. It was extremely difficult, from the appearances, to ascertain whether any fire accompanied the blast or not. The bodies when found in the board-gates some were of opinion had been burnt, and some that they were not. I did not see the bodies, and could not therefore give an opinion. There were no decisive appearances in the pit to indicate that there had been fire in that portion of the pit, viz., the south side. The blast had gone with extreme force against the faces of the board-gates and levels, where the men were working, and whether there was any fire along with the blast in those places or

not we could not ascertain. The after-damp would be almost equally fatal to life. The men appeared generally to have been struck down and killed upon the places where they were sitting. I could not, of course, state that of my own knowledge. We are obliged to enquire into the various circumstances, and the effect of the fire, to enable us to give an opinion. I have already stated that the violence of the explosion was very great at the faces of the board-gates. That was apparent from the effects which had been occasioned by the explosion, and by the destruction of the timber and plates, or the rails in the workings, and I observed a spade driven into a slip of the coal with very great force, showing clearly in what direction the blast had gone. Then, as regards the north side of the pit. We made a similar examination of this portion of the pit, and endeavoured to ascertain in like manner in what part of the workings the explosion had first taken place. The direction indicated by the stoppings and doors being blown down was not so decided as on the south side. In some cases the stoppings were blown towards a benk in one part of it, and in another part they were blown in a contrary direction. We examined with particular care the appearances of the dust, and the appearances of fire upon the sides of the coal, and in some places we found what we considered were decided marks of fire occasioned by the explosion, and in some other places there was no doubt upon the subject. We found pieces of coke or cinders formed by the action of the explosion upon the dust and coal of the mine. We examined very particularly the extent and appearances of the standing fire which had been produced by, and at the time of the explosion, and to extinguish which the water was poured into the mine. We found that such fire had extended a considerable distance to the north and west of the shafts, and partly, but not to so great an extent, to the south. It was somewhat difficult to judge, or to distinguish between the effects of the smoke and products arising from the standing fire of the coal, and the effects produced by the exploded gasses at the time of the explosion; still, in some places there were decided marks of the effects of the explosion on the dust of the mine and on the sides of the coal. These were more particularly observed in the Nos. 1 and 2 north benks, and in the slits of the No. 1 south benk. It was clear that gas had been fired or exploded in all those three benks, and I think there had been fire in the No. 3 north benk, but not to any extent, and not so clear as in the other cases. I will next endeavour to ascertain or explain how the gas had, in my opinion, been set on fire generally, or how or in what manner the gas in these benks was set on fire. In the

early part of my evidence, and in this paper, I pointed out that the bed of coal produced inflammable gas, and that the falls of stone consequent on the removal of the coal in the benks, would create or cause a magazine of such gas to accumulate in the goaves or cavities of these benks, and, therefore, I considered that the goaves of those benks were filled with inflammable air. We have also the fact that those benks or goaves were surrounded on three sides with naked lights; if, therefore, a fall of stone had occurred or taken place, it would force the gas out of those goaves or benks upon the naked lights, and so produce an explosion. In the Nos. 3 and 4 benks there were on the north side, falls of stone in the following-up benks, these falls would obstruct the air-way or the passage of the air up that side of the benk. This would produce two effects: first of all it would diminish the quantity of air in the benk itself, and the air by that obstruction would also be forced across the benk to the opposite side, and it might carry with it a portion of the gas accumulated in the upper cavities of the benk, from that side of the benk to the candles of the workmen on the opposite side, and so ignite it. We found on the opposite side of one of these benks, of the No. 3 benk, I think, two lamps with the tops off, which had been used by the men. The tops were screwed off, and had been used by the two men, who were working at the time of the explosion, in such a state. This might have caused the explosion. Then there is another mode by which the gas might have been ignited. It will be observed that the eastern extremity of No. 1 north, and No. 1 south benk, is about 70 yards from, and the air passes from these benks, towards the furnace. Now, a sudden fall of stone in either of these benks might have forced the gas out of these benks, and it might be ignited at the furnace. There is only, I think, one other way of accounting for the explosion, which is, that some of the doors which I have previously mentioned might have been left open, and the circulation of the air in consequence thereof might have been stopped or interrupted, and the air in some of the benks might thus be rendered inflammable. I am not, however, inclined to think that the accident occurred in this way. Upon considering those various modes in which the explosion might have occurred, we found extreme difficulty in assigning it to any one in particular of these cases. My opinion is, that it did not occur by igniting at the furnace. I think the probabilities lean towards its having been set on fire by the occurrence of a sudden fall of stone, forcing out the gas from the goaves upon the naked lights. It is not an improbable occurrence, although, from the evidence, it appeared that for months previously no

gas had been seen within the limits in which the workmen, from time to time, examine the goaves. It might be that at one moment the goaf might be examined, and might be found perfectly free from gas; and yet, at the next moment, a fall of stone might take place, and force the gas from the upper part of the goaf (where it could not have been seen) upon the candles. And this is the more likely, inasmuch as immediately above the coal there is a considerable thickness of very loose metal or shale, and above the shale some thick beds of hard rock or sandstone, and I believe some thin beds of coal associated with those harder beds. As the excavation of the benks increased in area, the first operation would be the falling of the loose shale immediately above the coal, there would then be a space between the top of these falls and the harder rock above, in which the gas would accumulate. At some period or other, when the area of the benks became sufficiently extended, the upper and harder rock would break down; and in that case, and at such a moment, would force out not only the gas which would be lodging at the top of the falls, but would probably carry with it an influx of gas from the thin beds of coal above. I think, therefore, it is very probable that something of this kind may have taken place, and have been the immediate cause of the explosion, forcing, as it would, the gas upon the candles. The mode in which the air was carried round the benks, operates also to induce the atmospheric air to cross the benks. This would render the benks or goaves still more dangerous, and therefore it is, that I consider it extremely dangerous to use any naked lights in such a mode of working. And I further take the liberty of stating that indications of having in the pit a large quantity of air, in which it is felt that the candles require sheltering, is no proof, under the circumstances which I have stated, to show that the pit is safe. A large quantity of air, if properly conducted, is essential to safety, but considering that it is quite impracticable to ventilate the goaves or benks so as to render them safe, the existence of that air might, if pressed through the benks, instead of adding to the safety, be, in fact, adding to the danger. The goaf when filled with pure inflammable air, without any admixture of atmospheric air, would be much safer than a goaf partially ventilated. Having given the subject all the consideration in my power, I think that the accident or explosion was occasioned, by the gas being forced upon the candles, in one of the following-up benks of either No. 1 north, No. 2 north, or No. 3 north, and No. 1 south. It is quite impossible to say in which of those benks the explosion first occurred. There has, in my opinion been

an explosion in all the four. An explosion in one of them by the concussion of the air would force the gas out of the other benks, and so produce an explosion in those benks. That was clearly ascertained in the case of the Darley Main Colliery, where an explosion at the extreme end of the workings, produced an explosion of a benk at the other end of the workings.

The PRESIDENT, after reading the document, proceeded to remark that, with respect to the mode of working, they would perceive that it was a modification of the long wall system, and in order to distribute the air around the workings, between fifty and sixty doors were used, and thus the whole safety of the mine depended upon them. Other collieries in the neighbourhood of Lundhill were worked on the same system, so that it became an important question for consideration, whether any and what improvement could be made in such a mode of working and system of ventilation. If, for instance, the Government Inspector of Mines knew that such a system was in operation, it might become a question as to what would be his duty regarding it, and whether or not it was incumbent upon him to report that such a system, with naked lights, was dangerous, and was likely to produce accidents? Adhering to the course of discussion previously recommended, the system of working would come first under discussion, and he proposed, in the first instance, therefore, to discuss the mode of working practised at the Lundhill Colliery.

Mr. DUNN—Was not the general principle of working by benks and board-gates?

The PRESIDENT—Yes; but it was by a particular mode, viz., by following-up benks, which consisted of working away the coal at the same moment in the face of the benks, and also on the two sides; and he asked if, under such circumstances, it could be safe to work with candles? It certainly was competent for the Government Inspector, if he did not consider it safe to use candles, in such a mode of working, to prohibit the use of candles, by declaring the pit not safe.

Mr. DUNN thought the whole system objectionable, and he supposed the Inspector would know his duty.

Mr. ATKINSON—It would be the duty of the Inspector to give notice, that he considered it was a dangerous practice, and if no notice were taken, to act according to his powers.

The PRESIDENT believed that Mr. Morton (the Government Inspector of the district), had been of opinion that it was not safe at the Lundhill Colliery to work with candles under such circumstances, and had given notice; and he believed that no candles had been used since the accident.

Mr. Boyd—Notice was not issued before the explosion.

The President—No, he believed not. There was no question, in his opinion, as to the danger of using naked lights in such a mode of working; where, as in the Lundhill Pit, gas was evolved in the leading board-gates. The system of following-up benks rendered it peculiarly dangerous.

Mr. Atkinson thought that if they had worked the entire width of the benks at one operation, without following-up benks, and there were an accumulation of gas in the goaves, then even in that case it might come out on the face, and so be ignited if naked lights were used.

Mr. Dunn considered that the innumerable doors in the pit were very objectionable.

The President—In some of the collieries in the Midland districts, where they so worked, they considered the mine safe if they excluded the atmospheric air from the goaf. It was admitted, that there might be gas in the goaf behind, but if the atmospheric air was excluded, and if it should be set on fire accidentally and exploded, the explosion would do no harm, as it would not explode in the goaf, but merely fly back to the edge of the goaf. There were, he believed, some collieries at present working under such circumstances, where there was little gas. As stated at the Darley Main inquest, at some of the Barnsley collieries, holes were left in the bearing-up stoppings, for the purpose of ventilating the goaf. It was clear that this mode of partially ventilating the goaf made it more dangerous than if it was properly ventilated, or not ventilated at all.

Mr. Boyd—There was a similar system practised in this district, but he believed it had been abandoned from not being considered safe with candles—safety-lamps being now exclusively used.

Mr. Berkley said he perceived, by the President's paper, that there were walls or pillars built on the sides of the goaves, which would give, in the first instance, partial support to the roof, but which would ultimately give way, and thus, most likely, cause falls in the goaves which would produce cavities in which gas would accumulate.

The President—That would be the case if the pillars were left standing, but in bringing up the following-up benks those pillars were taken away, leaving ultimately only one row of pillars on each side of the board-gate by the side of the goaf.

Mr. Dunn was of opinion that if the goaves produced a certain amount of carbonic acid gas, it would, in some degree, render the inflammable air innocuous.

The PRESIDENT stated that, at Monkwearmouth Colliery, some years ago, candles were used in working long walls, though the mine emitted gas; but lamps were now exclusively used. In the Midland districts, some collieries were still, he believed, worked with candles, under an idea, if an explosion did take place, the goaf not being ventilated, and there not being sufficient atmospheric air to render it inflammable, no harm would ensue. At the time of the Lundhill explosion, the whole of the air of the mine went over the furnace, and it was suggested that it had thus fired. Since the accident this had been altered, and at present the furnace was supplied with fresh air only—the air of the mine passing along a drift into the shaft without passing over the furnace. The management of the pit was now in the hands of Mr. Brown. That gentleman had made many improvements; the doors had all been doubled, and other improvements had been made, and the pit is now worked exclusively with safety-lamps. Mr. Brown had forwarded him a plan of the ventilation at present in operation (which he now produced to the meeting), which would show the progress made in the works since the accident, the alterations made in the ventilation, and some of the further improvements in the mode of working contemplated.

Mr. ATKINSON, referring to the plan, said there were darts crossing the doors. Did those indicate that there was a scale of air through the doors?

The PRESIDENT—No, it showed the direction of the pressure of the air only, he believed when the doors were shut they were quite tight. The number of splits of the air generally was not altered. There were the two divisions, one passing round to the south, and the other to the north, as heretofore, meeting together in the furnace-board; but instead of the air passing over the furnace, as it did at the time of the accident, it was now conveyed along a dumb drift into the pit, and did not pass over the furnace at all. The furnace was worked by air taken direct to it from the downcast shaft. The mode of distribution of the air around the pit, and into the respective workings, was the same substantially, as at the time of the accident, except the double doors instead of single. Mr. Brown informed him they had at present about 70,000 cubic feet of air passing round the workings. Coming now to the distribution of air around the workings, the meeting would see there were only two currents, each of 25,000 cubic feet per minute. No doubt two currents were better than one, but it was lamentable, notwithstanding what had been said and written on the increased quantities of air obtained by splitting the air,

it was not practised to such an extent as it might. Indeed, at ıner Colliery the evidence went to show that there was only one ·ent for the passage of the air, from the downcast to the upcast in the ourses; and in Yorkshire, and some of the other districts in the itting the air is scarcely, if at all, practised. No person entrust- he management of a mine in this country, and exhibiting ordinary h into the duties of his responsible office, can plead ignorance of t of the great advantage of splitting the air. We see at the dhill Colliery there are two currents or splits. This is, as before ed, no doubt, better than one; but the question is, can the split- f the air in that colliery be carried any farther to advantage? e are seven ways—or districts of workings. Can the air of this mine divided, with advantage, into seven splits? Mr. Brown states there ,000 cubic feet of air passing round the workings. If divided lly into seven splits, that would be 10,000 cubic feet of air for each Looking at the quantity of gas evolved in the mine (which was n in the evidence at the inquest), would 10,000 cubic feet of air pas- into each of those districts or ways per minute, be an adequate ·mount of ventilation? These were questions which he should wish to iscussed. It might be true that, in case of a sudden discharge of gas ır a blower coming off, the ordinary quantity of air might not be sufficient to immediately dilute it; but this would occur, in all probability, in the leading headings or drifts, and if safety-lamps were used, no harm could ensue. The question he proposed for discussion was, if a splitting of the air to the extent he named was practicable, and would be desirable?

Mr. Boyd—Would there be a sufficient number of air courses for a return?

The President presumed that if not sufficient at present they could be made so.

Mr. Atkinson said he thought, without altering the dimensions or number of the air ways, the resistance of the air would be so diminished by such a splitting of the air, that they would get seven currents of 15,000 cubic feet each, instead of seven of 10,000 cubic feet.

Some further discussion took place on this subject.

The President then said that, admitting the benefit of splitting the air, which no one could doubt, the question was, how was this to be accomplished? He had given as his opinion, both before committees of the House of Lords and Commons, that it was quite practicable to distribute the air in a mine along the main air-courses without any doors

at all, but by regulators. For instance, if it was thought advisable that separate currents or splits should be made to pass into the seven districts or ways at Lundhill Colliery, there would be no difficulty in doing so by regulators, and without doors. Some difficulty might, in the case of Lundhill Colliery, exist in the present mode by which the coal is worked, where two of the ways or benks, by working away the barrier between them, are laid into one. They would discuss this hereafter. But there would be no difficulty in laying out the workings to avoid this objection and to ventilate these different ways by separate and distinct currents—instead of two main currents, as at present—by regulators. There would be no difficulty, admitting that the air in the different ways had greater or less distances to travel, to so equalise the pressure or resistance by the different regulators, as that the quantity of air sent into each district should be equal in quantity, or in any other proportion which might be deemed advisable.

Mr. Hall was of opinion that it would be advisable to get an uniformity of air without doors, or by attending daily to regulators, though it might be found difficult at times to get the same quantity of air at the last regulator as at the first.

The President—It was only to so close the first regulator, or that which regulated the shortest current, to produce the same resistance as that of the last regulator, or that which regulated the longest current.

Mr. Berkley—How could they do away with the smaller doors, or doors in the workings?

The President—These were, he supposed, swing doors, which were used at the board-ends, and which were opened and shut by the trams. It was the main doors, on which the general ventilation of the mine depended, which would be superseded by the use of regulators; and he thought it a subject of much importance, and well worth the consideration of the members of the Institute, and of discussion, how far the ventilation of mines could be accomplished by regulators, instead of doors—the former not being liable to be neglected, as the opening and shutting of a door was, more especially as boys were almost universally employed for that purpose.

Mr. Atkinson thought it a very desirable measure; but the question was, why was it not done? They put in what was called shaft-doors, to prevent the air going direct from the downcast to the upcast shaft, and to divert the current into the pit; but it was not, in his opinion, necessary to have doors to direct the current into the different ways. Regulators

might be used for that purpose, and there would be no difficulty in equalising the pressure at each of the regulators so as to produce, or send into each way the desired quantity of air.

. Mr. HALL did not doubt that Mr. Atkinson's theory or opinion might be correct as to the pressure and uniformity of the air, if the 70,000 cubic feet per minute was the quantity; but circumstances might occur to produce a diminution in the quantity of air passing through the workings. For instance, if there were 35,000 feet instead of 70,000 feet per minute, that would reduce the quantity in each way to 5,000 feet per minute. If so, did Mr. Atkinson still expect the same relative quantity of air to pass through each regulator, without any alteration of them, as when the quantity was 10,000 feet per minute? And would Mr. Atkinson consider himself as safe from accident in the extreme way, as in the nearest way of the pits workings, taking into account that the gases in each way were coming off in equal quantities?

Mr. ATKINSON replied that he would consider himself as safe at the extremity of the workings, as in the nearest way, except as to the extra distance he had to travel in case of an accident. In his opinion the same relative quantity would pass through each regulator whether the aggregate quantity of air was 70,000 feet, or 35,000 feet per minute.

Mr. BOYD thought if the regulators required alteration in cases of irregularity of atmospheric pressure, there was no reason why they should not be attended to; an irregularity of air in any district would be the warning to those entrusted with the charge of the regulator to attend to it.

The PRESIDENT said that, as the subject of the relative quantities of air through regulators in cases of atmospheric irregularities, or other disturbing causes, was a subject of great practical importance, he suggested that for the present the discussion be confined to that subject, and, that they should for simplicity, take only two cases. One way or district with its regulator where the distance which the air travelled was three or four times that of another way with its regulator.

Mr. HALL still thought there was some doubt as to the per centage of air through each regulator being uniform, if the general quantity of air was altered.

Mr. ATKINSON stated that in some cases the regulators were never altered for years.

Mr. HALL—It would take some men to attend to the regulators.

The PRESIDENT said that undoubtedly the regulators would be placed

in the charge of some person or persons to see that they were performing the desired object. There were other causes, falls of stone, and interruptions in the air-courses, besides atmospheric influence, which might require the regulators to be attended to. For his part, he considered when once the proper comparative resistance to each current of air was produced by each regulator, that the regulators would not require alteration, except in unequal disturbances by interruption in the air-courses. A general diminution, or increase of a quantity of air by atmospheric influence, would not, except in some particular cases, cause a comparative irregularity in any district, and such cases being known to the persons in charge, the regulator would be consequently attended to. Theoretically, the temperature of each current being the same, an irregularity in the aggregate quantity, would not effect the several quantities comparatively; there were cases where the temperatures, from the dip or rise of the seam, were unequal; some irregularity might be produced, but as these would be well known, the regulators in cases of injurious disturbances would of course be attended to.

Mr. Atkinson—Ordinary attention to regulators would be sufficient to prevent danger in any length of run of the air.

A long and desultory conversation then took place, both on the subject of splitting the air, and also on the use of regulators instead of doors, and on ventilation generally; when it was arranged that the subject should be adjourned until the next meeting, which would be on the 3rd June, Mr. Atkinson promising that he would produce a paper on the subject.

The subject of the ventilating fan of M. Lemielle, by Mons. Laurent, was then brought before the meeting, and was partially discussed, but as Mr. Atkinson stated he would furnish the Institute with a paper on the relative power employed and consumption of coal by this machine, compared with some of the other modes of ventilation, it was thought desirable to postpone the discussion, until the paper of Mr. Atkinson was before the Institute.

The meeting then adjourned.

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ON THE

LEMIELLE SYSTEM

OF

VENTILATION OF MINES.

By Monsieur LAURENT.

Good ventilation is admitted to be the main point in the working of mines; it neutralizes and removes the causes of accident, which have too often proved fatal to the miners, and produces an atmosphere favorable to the health and activity of the workmen.

The constant formation of noxious gas necessitates a powerful and regular ventilation, capable of dispelling it as soon as formed. These two conditions in ventilation are indispensable to produce favorable results, for, if we have a powerful but irregular ventilation, the gas may accumulate and give rise to serious accidents, but, on the contrary, if the two conditions of power and regularity be united, the gas would then be carried off without intermission, and all danger be avoided.

The regularity of the coal seams in England and Scotland, and the ease with which they are worked, have contributed to the continuation, in these countries, of the old system of ventilation by the rarefaction of the air in the shaft by means of furnaces. This mode, without doubt, is the most simple, but, under certain circumstances, is dangerous, and serious accidents may and do arise therefrom, even with the greatest attention.

In the first place an explosion might so derange the furnace as to prevent its being used.

Secondly.—In many mines irregularities in working the furnaces, variations of the atmospheric temperature, and the distances and difficulties in the air passages are frequent causes of irregular ventilation.

THIRDLY.—In shallow pits, and even in deep pits habitually worked at a high temperature, little increase in the quantity of air in the mine can be made to meet sudden requirements, and in case of extended workings additional shafts only produce the requisite supply.

LASTLY.—The shaft, when heated to the extreme, say from 360° to 390°, produces, theoretically, a very small per centage of the effect obtainable by steam power; thus, 27 fathoms of depth give only 2¾ per cent., 55 fathoms 4½ per cent., 80 fathoms 6¼ per cent., 110 fathoms 9 per cent. only. If the shafts are used for drawing coals the heat rarely exceeds 104°, in which case the results obtained are more favorable, being 5½, 10⅔, 16, and 21⅓ per cent. respectively, and with a pit 325 fathoms may reach as much as 64 per cent. If it be taken into account that the practical results differ widely from theory, it will easily be conceived that in pits varying from 50 to 125 fathoms in depth, furnace ventilation is not the most economical.

A mechanical ventilation of simple construction, on the contrary, is regular, and, if sufficiently powerful, produces a uniform current of air, and gives a pure and invigorating atmosphere, in which the miner can work with ease. The first erections, it is true, are more expensive, but the prevention of danger and the greater amount of work of which the men are capable, more than compensate the first outlay.

Objections may be made to the use of machinery, owing to its liability to derangement, and the consequent stoppage of the supply of air, whereas, with furnaces, the shaft being heated, continues to work for some time after an accident.

In practice, however, it is found that with machines on the exhausting principle, the air and gases of the mine being in an expanded condition, on the sudden stoppage of the machinery, immediately contract in volume, and for a time the further issue of gas from the coal is arrested.

I now proceed to give the details of a ventilator invented by my friend Mr. Lemielle, well known both in France and Belgium for the excellent results obtained, and for which he was awarded a favorable testimonial, and a first-class medal from the French Government, and a medal from the Royal Academy of Sciences of Belgium.

The invention consists of a circular chamber of masonry, marked *A* in the accompanying sketch, which communicates by air passages with the shaft of the mine and exterior air. In this revolves a drum *B*, placed eccentric with the circumference of the chamber, to which are attached three or more fans or wings *CCC*, moveable at their base, whose outer

edge by means of the connecting rods *DDD*, attached to a shaft in the centre of the chamber, are kept in close proximity to the mason work. Motion is given to the drum by a horizontal steam cylinder, of simple construction, and, on reference to the drawings, it will be seen that each revolution of the machine will expel the air contained in the chamber. The first application of this apparatus was made in 1853, but, until 1855, it was little known, being, in the meantime, only under trial experimentally, but after the Paris exhibition of that year, its adoption became rapid, and, at present, it is in operation at upwards of ninety establishments in France and Belgium. The government engineers of both countries have, at different times, been called upon to test the effect of the apparatus in work, both as regards the proportion the quantity of air, drawn in or expelled, bears to its internal capacity, and also to its safety. From the various trials the loss has been found not to exceed ten to twenty per cent. of the theoretical volume of the apparatus; the loss depending to a certain extent on the state of the air passages in the mine. This small waste is accounted for by the slow speed of the ventilator, which makes only twenty to thirty revolutions per minute; the expulsion of air between the fans being nearly complete, and the escape very insignificant. It is well known that the various ventilators previously used revolve with greater velocity to produce any great current of air, and from the complicated machinery, are liable to rapid deterioration, whereas, in the Lemielle apparatus, toothed wheels, sheaves, belts, and fly-wheels, &c., are dispensed with.

In mines of great depth, where the ventilation is difficult, the Lemielle apparatus employed to withdraw 25,000 feet per minute, at thirty-five revolutions, need not exceed twenty horse-power, and for 75,000 feet per minute, at the same speed, a power of fifty horses would be sufficient, and so in proportion for a larger quantity; but in determining the power, of course, the distance to be travelled, and the dimensions of the air passages must be considered.

Owing to the simplicity of the engines, the repairs are trifling. They require what is common to all engines to ensure their good working, viz., cleaning and greasing. The machinery which has been at work for three or four years in Northern France and Belgium, has always worked well, and continues in good order, without having experienced any inconvenience from stoppage and repairs. A great advantage possessed by steam power over the former system, in case of accident, is that the speed of the apparatus may be augmented, and thus a larger quantity of air be

ıine, and considerably diminish the effects of the acci-
ı roceeds from an explosion or downfall. The machinery
e ıce is independent of accidents, and entirely under the
f the workman. An essential point to be observed is
ɔr can work up to a pressure of 4½ inches of water, in
ce, in ...any mines, where 2½ inches could not be exceeded by
the adoption of this has placed it on a more favorable
... ...lusion, I beg to observe, that my intimate knowledge
perience and the practical results obtained by the numerous
ıents where this system of ventilation has been adopted, have
me to address you on a subject of such vital importance in a
y possessing the richest coal-fields in the world, and where, I am
believe, a fair trial of the system would lead to its general adop-
nd would greatly conduce to the advantage of the owners, and to
being of the large population of miners who daily risk their
n this all-important branch of industry.

APPENDIX.

(I.)

Result of trial made by Mr. Dormoy, French Government Mining Engineer, of the Lemielle Apparatus, in the presence of Mr. Cabany, Engineer and Director of the Anzin Mining Company, the largest coal company in the North of France.

On the 28th January, 1856, Messrs. Armand Cabany, Chief Engineer and Director of the Anzin Mining Company, and Emile Dormoy, de la Garanne, Government Engineer of Mines, verified, by means of Combe's anemometre, the quantity of air extracted by Mr. Lemielle, in the St. Mary's Mine, concession of Azincourt, (near) Aniche, department of Nord.

The ventilator at first revolved at the rate of twenty-one revolutions per minute; after that, they increased the velocity to thirty-seven revolutions. They made eight successive experiments, of which the results were the following:—

At twenty-one revolutions the ventilator aspired 16,848 cubic feet per minute, with a pressure of 4-5ths of an inch; and at the rate of thirty-seven revolutions it aspired 25,920 cubic feet per minute with a pressure of two inches.

The theoretical calculations, with the dimensions of the apparatus, gave, for twenty-one revolutions, 18,576 cubic feet per minute; for thirty-seven revolutions, 32,724 cubic feet per minute; so that the loss while revolving slowly was 10 per cent., and at the increased velocity 21 per cent., giving a mean of 15 per cent. with an ordinary velocity.

(Signed) A. CABANY.
E. DORMOY.

(II.)

CERTIFICATES.

The undersigned Engineer and Manager of the Aniche Coal Mining Company (Nord), certifies that he has had erected two ventilators on the Lemielle system—the one in 1856, and the other in 1857; that both these ventilators have worked to his complete satisfaction, from their first establishment up to the present time, and that they still continue to work in good order.

(Signed) VUILLEMIN.

Aniche (near Douai), the 24th March, 1858.

I, the undersigned Director of the Mines of Azincourt, certify that the ventilator which Mr. Lemielle furnished us with in 1855, has always worked well, and that it continues to ventilate our works without being worked to its full power.

It is to this system that we shall have recourse if we require a ventilator for our new works.

(Signed) F. BERDOLIN.

Aniche, near Douai (Nord), the 24th March, 1858.

I, the undersigned Engineer of the Coal Mines of Escarpelle, near Douai (Nord), certify that Mr. Lemielle has supplied me with a ventilator for one of the pits of the above company, and that it produces all the results stated by its inventor.

(Signed) PENBOISSET, the Engineer of the Company.

L'Escarpelle, the 24th March, 1858.

(III.)

LIST OF THE PRINCIPAL COMPANIES IN FRANCE AND BELGIUM USING THE LEMIELLE VENTILATOR.

Grande Machine a feu de Dour appartenant à M. le Baron de Mecklenbourg	1
Société de l'Esperance à Seraing	2
Id. du Nord du Bois de Boussu	1
Id. de Sclessin (Liége)	9
Id. Cockerill à Seraing	1
Id. des Grands Romarains Kessales à Jemeppe (Liége)	2
Id. Marihaye et Female Grande à Seraing	4
Id. Saint Martin à Marchienne-au-pont lez Charlerg	2
Id. d'Epinac (Saone et Loire)	1
Compagnie des Mines d'Anzin	3
M. Desprez à Anzin	1
Mines d'Azincourt	1
J. Cail à Denain	1
Société de Marimont	1
Id. de Strepy Bracquegnies M. de Laroche	2
Id. du Bois Jemmapes (Fleunu)	1
Id. des Charbonnages Reums	1
Id. des Produits à Jemmapes (Fleunu)	4
Charbonnage de Bonne Espérance et Bonne-Veine appartenant à M. Boulogne	2
Société du Midi de Dour	1
Haine Sains-Pierre	1
Société d'Aniche	1
Compagnie des mines de Montralais et Mouseil prés Nantes	1
Id. Vicoigne	1

Et en dernier lieu la Compagnie des mines d'Anzin, qui vient de traiter pour ses exploitations en général.

MECHANICS INST.

ON THE COMPARATIVE

]ONSUMPTION OF FUEL

BY

ITILATING FURNACES AND VENTILATING MACHINES,

WHEN USED TO VENTILATE MINES.

By John J. Atkinson.

WITHSTANDING the important advantages attending the use of fur-
s for ventilating mines, compared with the employment of ventilating
ines for that purpose, I am yet inclined to think that the best known
iptions of ventilating machines, when worked by steam-power, if
ted to replace furnace-action, would, in almost all cases, effect a
ıg of fuel, when producing the same amount of ventilation as that
ıg from the furnaces superseded by them; in other words, if a ven-
ing furnace and its upcast shaft be considered as a machine, through
nedium of which, the power, due to the fuel consumed, is applied
e work to be done, then, I think, that it will generally be found to
ıferior, as regards the effectual or useful duty obtained from a given
ıtity of fuel, to the best descriptions of ventilating machines worked
team-power.

he quantity of coals required to be consumed in a ventilating furnace,
oduce a given amount of ventilation in the unit of time, will vary
h, under the differing circumstances of different mines, and depends
or less on the following conditions, and a few others, generally
ıinor importance:—

t.—The amount of the specific resistance, or "*drag*" of the mine and shafts.

ıd.—On the amount of ventilating pressure due to a given excess of average temperature prevailing in the upcast, over that prevailing in the downcast shaft; and this, again, depends upon the depths

and relative positions, as to level, of the tops and bottoms of these shafts, and on the temperature of the atmosphere, as affecting that of the air in the downcast shaft, and on that of the workings, as affecting the heat to be imparted by the furnace to the return air, in order to realize a certain excess of temperature in the upcast, over that prevailing in the downcast shaft.

3rd.—On the cooling power of the upcast shaft, as affected by its comparative degree of dryness or moisture, and the heat-conducting properties of the materials composing its walls.

4th—On the loss of heat by cooling in the upcast shaft and furnace drift, as affected by the time during which the air is exposed to them; depending partly upon the area and length of the furnace drift, the area and depth of the upcast column of air, the quantity of air circulating per minute, and upon the elevation of the temperature required for its production.

Now, the consumption of fuel to drive a steam-engine, to produce ventilation through the medium of a ventilating machine, also depends upon a number of conditions, which will likewise vary to a great extent with the differing circumstances of different mines, and depends on the following conditions, and a few others of less importance:—

1st.—The amount of the specific resistance, or "*drag*" of the mine and shafts.

2nd.—On the relative temperatures prevailing in the downcast and upcast shafts; any excess of temperature in the upcast over that in the downcast, operating in creating a ventilating pressure in aid of the engine, and so reducing the quantity of coals to be consumed, on the one hand; while, at the same time, it increases the volume of the air to be passed through the machine in a given time, and thus requires a greater speed and consequent consumption of fuel in the engine, on the other hand.

3rd.—On the comparative efficiency of the machine employed, the power required to overcome the friction of its working parts, and particularly upon the resistance which the machine presents to the passage of the air through it; the amount of which varies greatly with the form, dimensions, and mode of operation of the machine employed.

Since the amount of coal required to be consumed for the production of ventilation, depends upon so many conditions, which vary more or less in different collieries; and since the amount of duty obtainable from a

given quantity of coal consumed, where furnace-action is employed, varies so rapidly with the depth of the upcast, and also with its cooling power, it will perhaps be best, for the purpose of this memoir, to make a general comparison on supposititious conditions, in the first place; and afterwards to calculate the consumption of fuel which would require to be expended to produce the same ventilation, by means of the best descriptions of ventilating machines, were they to be substituted for the furnaces by which such ventilation is produced, in a few known cases of furnace ventilation, where we have the requisite data to enable us to do so.

In order to simplify the general formula of comparison, as far as may be practicable, without seriously affecting the results, there are certain peculiar sources of resistance in furnaces, and others in ventilating machines, of small though variable amount; and also certain peculiarities affecting the ventilating pressure in each case, likewise of small though variable amount, in different collieries, which will be taken to balance each other.

For instance, where furnace-action is employed, there is an extra amount of volume and velocity in the air, in the furnace drift and the lower part of the upcast shaft, arising from that part of the expansion which is due to the temperature lost by cooling, and this creates a slightly greater resistance in these parts, than would exist if a ventilating machine were employed to produce ventilation.

Again, in furnace ventilation, there is a slight increase of density in the upcast column, due to the carbonic acid, resulting from the combustion of the coal in the furnace, operating in reducing the motive column; but this is only to the extent of 1½ parts out of 1,000 when 1 lb. of coal gives 10,000 cubic feet of air.

On the other hand, when ventilation is produced by an exhausting ventilating machine, the machine has to traverse a greater distance than is due to the volume of air exhausted, owing to the expansion of the air arising from the motive column or ventilating pressure being taken off the atmospheric pressure in the machine; but this is always of small amount, because, while the pressure of the atmosphere may, on the average, be represented by 400 inches of water column, if we presume the ventilating pressure to be equal to two inches of water-guage, the expansion of the air, and consequently the velocity of the machine, will only be increased about five parts out of 1000, or ½ per cent; and on the other hand, the upcast column will be lightened to some extent by this expansion, and thus produce a slight increase in the motive column of air.

There is also a loss of temperature in the upcast column, where a

ventilating machine is used, owing to the expansion of the air in ascending from the bottom of the pit to the top, where the barometrical pressure is less than that prevailing at the bottom of the pit, at the rate of about 1° for 34 fathoms of depth, giving a loss of temperature in the upcast shaft (on the average of the entire depth) of 1° for every 68 fathoms in depth; owing to which, the average upcast temperature, instead of being that of the return air, when a ventilating machine is employed, will be 1° less for every 68 fathoms of depth.

The peculiar sources of discrepancy arising from the mere substitution of a ventilating machine for furnace action, which have just been noticed, are, it will be observed, very small in amount, and as some of them operate only against the use of furnaces, and others only against machines; they will in all cases be excluded from the calculations to be given in this memoir.

In like manner, any difference of density in the upcast compared with the downcast column, arising from changes in the hygrometrical state of the air, or from gases given off by the mine, will be treated as operating equally in favour of or against ventilation, whether furnace action or machine ventilation is used, and, consequently, excluded from our calculations in comparing the one system with the other; as, any ventilating pressure arising from, or absorbed by, these sources, will operate equally in favour of or against furnaces and ventilating machines.

Let the following symbols be adopted :—

Q = Volume of air per minute, at the temperature r, in cubic feet.
f = Atmospheric pressure, in inches of mercury reduced to 60°.
r = Temperature of the return air (Fahrenheit's scale).
T = Average prevailing temperature of the upcast shaft.
s = Specific heat of air, taken at ·27, water being unity.
q = Calories or units of heat produced by each lb. of coal supplied to the furnace.
F = lbs. of fuel used per minute.
C = cwts. of fuel used per day of 24 hours.
f = lbs. of fuel per horse power (exclusive of the power due to natural ventilation) per hour.
p = Per centage of power lost by cooling in upcast shaft.
p′ = Per centage of power lost by resistances in ventilating machines.
d = Depth, vertically, from furnace to top of upcast column, in feet.
H = Horses power due to the quantity Q, including the power applied by furnaces or machines, and also that resulting from the temperature of the mine.

h = Horses power due to the artificial ventilating agent, whether it be a furnace or a machine.

f' = lbs. of coal per horse power per hour, taking the power due to natural ventilation as if it were due to the artificial ventilating agent.

Now, when furnace action is employed to produce ventilation, the total volume of the air to be heated, each minute, by the furnace, is Q, taken at the temperature of the return r; the weight per cubic foot of air at this temperature is $\frac{1{\cdot}3244\ f}{459 + r}$*; and hence the entire weight in lbs. of air to be heated by the furnace, each minute, is $\frac{1{\cdot}3244\ f}{459 + r}\ Q$; and the degrees of heat to be imparted to it, over and above those which are lost by cooling in the furnace drift, and in the lower portion of the upcast shaft, before it reaches the point where the average temperature of the total upcast column prevails, is T − r, giving $\frac{1{\cdot}3244\ f}{459 + r}\ Q\ (T - r)\ s$, for the calories or units of heat contained in the air which each minute passes the point of the upcast where the average temperature T prevails, over and above the heat contained in the same air, on reaching the furnace, with the temperature of the return r; and the quantity of coals, in lbs., per minute, due to the production of this heat is, therefore,

$$\frac{1{\cdot}3244\ f\ Q\ (T-r)\ s}{(459 + r)\ q} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [1]$$

And since p is the per centage of heat imparted by the furnace to the return air, which is dissipated and lost by cooling in the furnace drift and the lower part of the upcast column before the air reaches the point where the average temperature T of the upcast prevails, it follows that, when furnace action is employed, the quantity of fuel consumed per minute in lbs. is,

$$F = \frac{1{\cdot}3244\ f\ Q\ (T - r)\ s}{\left(1 - \frac{p}{100}\right)(459 + r)\ q} \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

Now, in order to find an expression for the quantity of fuel, required to be consumed by an engine driving a ventilating machine, in a case where a furnace has been previously employed to produce the same amount of ventilation, we have the ventilating pressure required to be produced by the machine expressed by the excess of $d\left(\frac{T - t}{459 + T}\right)$, the

* See Transactions, Vol. III., p.104.

actual pressure which prevailed when the furnace was used, over the pressure which would have resulted from the temperature of the return air only, in the upcast shaft, viz., $d\left(\frac{r-t}{459+r}\right)$; or, by $d\left(\frac{T-t}{459+T} - \frac{r-t}{459+r}\right)$, in motive column of air, at the temperature t; seeing that this pressure, on the grounds assumed, would be the only pressure to be created, either by a furnace or by a machine; as the temperature and pressure due to the return air is presumed to be the same in each case. And as $\left(\frac{1{\cdot}3244\,f}{459+t}\right)$ is the weight, in lbs., per cubic foot, of air at t, the pressure per superficial foot, in lbs., is

$$\frac{1{\cdot}3244\,f}{459+t}\,d\left(\frac{T-t}{459+T} - \frac{r-t}{459+r}\right) \ldots\ldots\ldots\ldots\ldots [3]$$

and the horses power due to this pressure, when the quantity Q is circulating per minute, is, exclusive of all power wasted,

$$h = \frac{1{\cdot}3244\,f\,Q\,d}{33000\,(459+t)}\left\{\frac{T-t}{459+T} - \frac{r-t}{459+r}\right\} \ldots\ldots\ldots\ldots [4]$$

and since, if all the power were utilized, we should have $h\,f = 60\,F$, as the fuel consumed per hour, it would follow that $h = \frac{60\,F}{f}$, which, combined with [4], if there were no power wasted, would give

$$F = \frac{1{\cdot}3244\,f\,Q\,d\,f}{1{,}980{,}000\,(459+t}\left\{\frac{T-t}{459+T} - \frac{r-t}{459+r}\right\} \ldots\ldots [6]$$

But, since p′ is the per centage of power wasted, in the application of the ventilating machine, $\left(1 - \frac{p'}{100}\right)$ is the proportion of power and fuel utilized. And the real consumption of fuel, by the engine driving the ventilating machine, thus becomes

$$F = \frac{1{\cdot}3244\,f\,Q\,d\,f}{\left(1 - \frac{p'}{100}\right)(459+t)\;1{,}980{,}000}\left\{\frac{T-t}{459+T} - \frac{r-t}{459+r}\right\} \ldots [7]$$

Now, as we consider a pit to become deeper and deeper, it will gradually approximate to a particular depth, where the coals required to be consumed in a furnace, to produce a given ventilation, other things being constant, will be exactly equal to the coals required to produce the same ventilation, through the medium of a ventilating machine; and the particular depth at which this equality in the consumption of coals is reached is evidently that at which the right hand members of equations [2] and [7] become equal to each other, or

$$\frac{1{\cdot}3244\, f\, Q\, (T - r)\, s}{\left(1 - \frac{p}{100}\right)(459 + r)\, q} = \frac{1{\cdot}3244\, f\, Q\, d\, f}{\left(1 - \frac{p'}{100}\right)(459 + t)\, 1{,}980{,}000} \left\{ \frac{T - t}{459 + T} - \frac{r - t}{459 + r} \right\}$$

For the sake of this general comparison, let us now presume the temperature of the return air to be the same as that of the downcast shaft, seeing that any effects produced by its being hotter, operate equally, whether a furnace or a machine is used, and the equation becomes then

$$\frac{s}{\left(1 - \frac{p}{100}\right) q} = \frac{d\, f}{\left(1 - \frac{p'}{100}\right) 1{,}980{,}000\, (459 + T)} \quad \ldots\ldots\ldots\ldots\ldots [8]$$

from whence,

$$d = \frac{\left(1 - \frac{p'}{100}\right) 1{,}980{,}000\, (459 + T)\, s}{\left(1 - \frac{p}{100}\right) f\, q} \quad \ldots\ldots\ldots\ldots [9]$$

If we further admit the loss of fuel, in furnaces, by cooling in the upcast; and in ventilating machines, by the power expended in overcoming all the useless resistances arising from the use of the ventilating machine, (including the power required to pass the air through the machine, and also the friction of the working parts of the machine,) to be equal to each other; and if we further take the specific heat of the air at ·27, to that of water as unity, (although it will slightly vary with the temperature and pressure,) we obtain

$$d = \frac{1{,}980{,}000 \times {\cdot}27\, (459 + T)}{f\, q} \quad \ldots\ldots\ldots\ldots\ldots\ldots [10]$$

And if we further take the quality of the coal to be such as that each lb. of coal used shall give out the average quantity of 13,000 calories or units of heat, we then get

$$d = \frac{41{,}123\, (459 + T)}{f} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [11]$$

from which it appears that the depth at which furnace action becomes as economical in fuel as a ventilating machine, increases directly as the volume assumed by a given weight of air as due to the average upcast temperature required for the production of ventilation by furnace action; that is to say, inversely as the average density of the heated air in the upcast. This depth, of course, must decrease in the same proportion that the fuel per horse power, per hour, required to drive the engine of a ventilating machine increases, as evinced by the formula [11].

By this formula [11] the following table has been calculated, showing

the depths at which furnaces become equal to ventilating machines in point of economy of fuel, assuming that the sources of loss are the same in the two cases, as has been already stated:—

TABLE I.

Consumption of Coal by Engine, in lbs. per hour, per horse-power expended	AVERAGE TEMPERATURE OF UPCAST COLUMNS.		
	100° Fah.	150° Fah.	200° Fah.
	Depth in Fathoms.	Depth in Fathoms.	Depth in Fathoms.
8	479	522	565
10	383	417	452
12	319	348	376

It may, however, be supposed by some who have not investigated the matter, that there is generally less loss of fuel by cooling in furnace drifts and upcast shafts than the per centage of fuel lost in passing air through a ventilating machine, and in overcoming the friction of the working parts of the machine itself; and if so, they may perhaps conclude that the above comparison is not made on terms generally so fair towards furnaces as towards machines.

In order to show that, in general, there is a very considerable loss of heat by cooling in upcast shafts, from its amount in a number of cases, the following table is submitted, showing the amount of such loss at the places named in it. The data are selected from Tables B and C in Appendix No. 1 of the Third Report of the Select Committee on Accidents in Coal Mines, dated July, 1853, and are, I believe, either all or in part founded upon data collected by Professor Phillips. The tables were given in evidence by the President of this Institute, Mr. Wood.

TABLE II.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Names of Collieries.	Coals used at the furnace in 24 hours = C.	Quantity of air in circulation per minute = Q.	Depths of pits = d.	Average temperature of the upcast shaft = T.	Average temperature of the return air = r.	Excess of upcast temperature above return air = T − r.	Relative volume of return air to 459, as vol at zero Fah. 459 + r.	Heat from the Furnace. Conserved at point where T is the temperature.	Heat from the Furnace. Lost before reaching the point where T is the temperature
	Cwts	Cubic Feet.	Feet.	°	°	°		Per Cnt.	Per Cnt.
Seghill	60	42,708	?	122	62	60	521	86·97	13·03
Thornley, Hutton Seam	48	26,574	868	79	65	14	524	15·69	84·31
„ ¾ Seam	48	45,756	556	94	69	25	528	47·88	52·12
Wingate Grange	56	45,000	?	120	69	60	519	98·56	1·44
Walker	29¾	44,800	960	98	72	26	531	78·23	21·77
Castle Eden	45	42,326	1038	103	63	40	522	76·47	23·53
Wearmouth	30	70,500	1800	84	75	9	534	42·02	57·98
South Hetton	110	132,895	1212	90	72	18	531	43·45	56·55
Percy Main, High Main	24	18,805	?	94	65	29	524	46·00	54·00
„ Bensham .	45	35,893	?	116	66	50	525	80·59	19·41
Mickley	18	15,000	?	77	56	21	515	36·05	63·95
Totals	513¾	520,257			Total			651·91	448·09
Average per lb. of coal	=	13,019			Average			59·27	40·73
The following have been omitted from the above Table, because it is impossible that the coals could heat the quantities of air to the extent stated in the Tables.									**Minus.**
Willington	**70**	**66,500**	**840**	**138**	**64**	**74**	**523**	**142·61**	**42·61**
Felling	**72**	**63,000**	**696**	**128**	**66**	**62**	**525**	**109·63**	**9·63**
Wallsend, A Pit	**28½**	**27,000**	**900**	**135**	**69**	**66**	**528**	**125·64**	**25·64**
„ B Pit	**28½**	**45,100**	**900**	**130**	**69**	**61**	**528**	**193·97**	**93·97**
„ F Pit	**32**	**48,260**	**900**	**110**	**70**	**40**	**529**	**120·99**	**20·99**
West Auckland.....	**18**	**14,478**	**?**	**120**	**54**	**66**	**513**	**109·79**	**9·79**

The per centage of the excess of temperature, added to the return air, by furnace action, which has been lost before reaching that part of the

upcast shaft where the average upcast temperature prevails, as exhibited in column 10 of this table, has been calculated from a formula, arising from taking [1] to represent the lbs. of coal per minute due to the production of the temperature which prevails in the upcast column at the point of average temperature, viz., $\frac{1{\cdot}3244\, f\, Q\, (T - r)\, s}{(459 + r)\, q}$ and since the actual consumption of coals in lbs. per minute is, $F = \frac{C \times 112}{24 \times 60}$ we obtain for the per centage of the furnace heat conserved at that point

$$\text{As } \frac{C \times 112}{24 \times 60} : \frac{1{\cdot}3244\, f\, Q\, (T - r)\, s}{(459 + r)\, q} :: 100$$

$$: = \frac{1{\cdot}3244\, f\, Q\, (T - r)\, s\, 100 \times 24 \times 60}{(459 + r)\, q}$$

as exhibited in column 9 of the table, this formula becomes, on taking the barometrical pressure $f = 30$ inches of mercury, the specific heat of air $s = {\cdot}27$, to that of water as unity, and the units of heat yielded by that part of the coal which is actually burnt, to be equivalent to the production of 13,000 calories or units of heat per lb. of coal supplied to the furnace, so as to allow for the part which is not burnt, but wasted as cinders, &c.

$$\frac{1{\cdot}061\, Q\, (T - r)}{C\, (459 + r)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [12]$$

from which, column 9 has been calculated; and column 10 is merely the excess of 100, over the quantities exhibited in column 9.

Now, in Table I. we have ascertained the depths at which furnaces become as economical in fuel as machine ventilation, on the presumption that the fuel due to the temperature lost between the furnace and the point in the upcast column, where the average temperature prevails, is the same per centage of the whole fuel, as that which arises from the application of ventilating machines, driven by engine power, to produce the same ventilation; and now, since we perceive from Table II. that the average of this loss in eleven cases of furnace action has been forty per cent., it follows, that if we have ventilating machines losing forty, and utilizing sixty per cent. of the engine power, the depths that are necessary, (supposing, even, that the loss of temperature did not increase with the increase of depth), to render furnace ventilation as economical as such ventilating machines in the consumption of fuel, are those stated in the Table I.

That several kinds of ventilating machines do utilize this per centage of the engine power, may probably be admitted, from what follows.

In Appendixes Nos. 2 and 3 to the Report of the Select Committee on Accidents in Mines, dated 30th June, 1853, from certain papers given in evidence by Mr. Mackworth, we obtain the information conveyed by the following table, respecting certain ventilating machines :—

	(1) Quantity of Air extracted per Minute.	(2) Water Gauge.	(3) Horses Power expended.	(4) Horses Power utilized.	(5) Per Centage of Power utilized.	(6) Coals used per Horse Power expended per hour.	(7) Coals used per Horse Power utilized per hour.
	Cubic Feet	Inches.				lbs.	lbs.
Fabrey's Fan	19,758	1·96	10·37	6·22	·60	12·2	21·5
Fabrey's Pnuematic Wheels from expmts. by M. Jochams, Engineer of Mines.	20,330	0·88	5·37	2·81	·52	14·4[3]	27·6
	21,500	1·6	10·37	5·41	·52	12·10	23·2
	15,817	2·4	8·95	5·97	·67	11·4	17·2
	14,776	3·0	11·21	6·97	·62	11·2	18·04
	8,912	3·44	8·46	4·82	·57	11·28	19·82
Struve's Ventilator at Eaglesbush	16,950	1·55	5 85	4·14	·70	15·9	22 46*
Average..	....	....	....	..	·58	..	..

* Steamways of Engine contracted.

From this table it may be seen that, in two of the experiments on Fabrey's pneumatic wheels, and in that on Struve's ventilating machine, more than 60 per cent. of the engine power was utilized; and I was informed by a French gentleman, a few days ago, that 69 per cent. of the power had been utilized in one case by Fabrey's wheels.

Having now made a general comparison, as regards the consumption of fuel, between the best descriptions of ventilating machines and furnaces for the production of ventilation, let us proceed to consider what the results would be, in a few particular cases, if the best kinds of ventilating machines were substituted for furnaces.

If we would separate the power, arising from the heat added to the air by the furnace, from that which would operate if the mere temperature of the return air prevailed in the upcast shaft, since $d\left(\frac{T-t}{459+T}\right)$ is the total air column at t, due to the combined effect of the furnace and the heat imparted to the air by the workings of the mine, and $d\left(\frac{r-t}{459+r}\right)$ is the motive column in air at t, due only to the heat given off by the mine, it follows that the motive column in air at t, due alone to the furnace action, is the difference,

$$d\left\{\frac{T-t}{459+T}-\frac{r-t}{459+r}\right\}\ldots\ldots\ldots\ldots\ldots\ldots\ldots[13]$$

so that the pressure per superficial foot, due to the heat conserved from the furnace, at the point of average temperature in the upcast shaft, is

$$\frac{1{\cdot}3244\,f}{459+t}\,d\left\{\frac{T-t}{459+T}-\frac{r-t}{459+r}\right\}\ldots\ldots\ldots\ldots\ldots[14]$$

and since this is the only part of the ventilating pressure required to be produced by the artificial ventilating agent, whether it be a furnace or a machine, as the remaining part of the ventilating pressure arises from the heat imparted to the air by the mine, and operates equally whether a furnace or a ventilating machine be used to obtain the remainder, it results that the artificial ventilating power exerted in each case is,

$$h=\frac{1{\cdot}3244\,f\,Q\,d}{33{,}000\,(459+t)}\left\{\frac{T-t}{459+T}-\frac{r-t}{459+r}\right\}\ldots\ldots\ldots\ldots[15]$$

and since this is the real power given off by the furnace, and is the same in amount as would be required in a ventilating machine to produce the same amount of ventilation in the same mine, it will be proper to divide the fuel consumed per hour, in the cases of furnace action, by this power, to obtain the consumption of fuel per horse power per hour, to compare with what would be required to give the same power and ventilation by a ventilating machine; and since the consumption of fuel in lbs. per hour is $\frac{C\times 112}{24}$, this division gives

$$f=\frac{\frac{C\times 112}{24}}{\frac{1{\cdot}3244\,f\,Q\,d}{33{,}000\,(459+t)}\left\{\frac{T-t}{459+T}-\frac{r-t}{459+r}\right\}}\ldots\ldots\ldots\ldots\ldots[16]$$

and by taking the barometrical pressure, f = 30 inches of mercury, and reducing, we obtain

$$f = \frac{3875{\cdot}872\ C\ (459 + t)}{Q\ d\left\{\frac{T - t}{459 + T} - \frac{r - t}{459 + r}\right\}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [17]$$

From this formula [17], the coals consumed per horse-power, per hour, contained in column 12 of the following table, have been calculated. Column 13, in the same table, shows what would be the consumption of fuel by an engine consuming 12lbs. of coal per horse-power, expended per hour, and utilizing sixty per cent. of such power, when applied to drive a ventilating machine; which is equivalent to a consumption of $\frac{12 \times 100}{60}$ = 20lbs. of coal per horse-power utilized, per hour. If the engine utilized fifty per cent. only of the power, the fuel per horse-power utilized, per hour, would then become 24lbs., in lieu of 20lbs. as in the table.

In constructing this table of comparison, all the cases given in Table II. will be taken, excepting those where the depth of the pit is not stated, and those which profess to have got more heat out of the coal than it was capable of yielding.

An examination of the resulting table will show that in the six cases given, the depths vary from about 93 up to 300 fathoms; the average upcast temperatures from 79° to 103°; the downcast temperatures from 41° to 62°; the temperatures of the return airs from 65° to 75°; the cubic feet of air, per minute, from 26,574 to 132,895; the heat of the furnace, above that of the return air, conserved at the point of average temperatures in the upcast, from 15·69 to 78·23 per cent.; and the coals consumed per horse-power exerted by the furnace, exclusive of the power of natural ventilation, from 27·2 to 162·4lbs. per hour, compared with 20lbs. per horse-power, per hour, due to a ventilating engine consuming 12lbs. per horse-power, per hour, and utilizing sixty per cent. of the power expended.

TABLE IV.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
NAMES OF COLLIERIES.	Coals consumed by furnace in 24 hours = C.	Depths of pits taken as upcast column = d.	Average temperature of the upcast column = T.	Average temperature of the downcast column = t.	Average temperature of the return air = r.	Volume of air at T, compared with 459, as volume at zero = 459 + T.	Excess of upcast over downcast temperature T — t.	Degrees of temperature given to air by the mine r — t.	Per Centage of excess of upcast over downcast temperature due to mine.	Per Centage of excess of upcast temperature over downcast temperature due to furnace.	Coals per horse-power utilized per hour, excluding the power due to the mine; as observed by furnace action.	Coals per horse-power, per hour, due to a ventilating machine, utilizing 60 per cent., and engine using 12lbs. per horse-power, per hour.	Coals per horse-power, per hour, due to the united power of the furnace and the heat from the mine.	Per centage of the heat given out by furnace which remains in the air in the upcast at the point where the average temperature prevails.	Quantity of air circulating per minute = Q.
	Cwts.	Feet.	°	°	°	Relative Volume.	°	°	℘ cent.	℘ cent.	lbs.	lbs.	lbs.	℘ Centum	Cubic Feet.
Thornley 5-4 Seam ...	48	556	94	42	69	553	52	27	52	48	85·4	20	37·5	47·89	45,756
,, Hutton Seam	48	868	79	41	65	538	38	24	63	37	162·4	20	57·1	15·69	26,574
Walker	29¾	960	98	49½	72	557	48½	22½	46	54	30·5	20	15·6	78·23	44,800
Castle Eden.....	45	1,038	103	62	63	562	41	1	2	98	29·1	20	28·3	76·47	42,326
South Hetton	110	1,212	90	52	72	549	48	20	42	58	27·2	20	15·5	43·45	132,895
Wearmouth.....	30	1,800	84	52	75	543	32	23	72	28	29·5	20	7·9	42·02	70,500
Average.....	..	..	..	..	..	..	..	..	..	..	60·7	20	27·6	50·62	Average.

Column 14 in the table just given has been calculated on the principle of supposing that the ventilating power due to the heat given off by the mine, was part of the power due to the furnace, and that it would not operate if a ventilating machine were employed, and is rather given as a matter of curiosity than as being a fair criterion whereby to estimate the fuel consumed in furnace action in comparison with what would be required in a ventilating machine to supersede it, as it has mostly, hitherto, been usual to embrace the effects of this (often important) source of ventilation in calculations relative to the power of furnaces. The formula by which the column in question has been calculated, arises from adopting $d\left(\frac{T-t}{459+T}\right)$ as the motive column in air at t, the weight, per cubic feet, of such air being $\frac{1{\cdot}3244\ f}{459+t}$, and hence the pressure per superficial foot $= d\left(\frac{T-t}{459+T}\right)\left(\frac{1{\cdot}3244\ f}{459+t}\right)$, and the dynamical units or foot-pounds due to the quantity Q, circulating per minute, is $= Q\ d\left(\frac{T-t}{459+T}\right)\left(\frac{1{\cdot}3244\ f}{459+t}\right)$ and the horses-power represented by this is

$$H = \frac{Q\ d\left(\frac{T-t}{459+T}\right)\left(\frac{1{\cdot}3244\ f}{459+t}\right)}{33{,}000}$$

and, on this hypothesis, the lbs. of fuel consumed per horse power, per hour, would be, in lbs.,

$$f' = \frac{C \times 112}{24} \div \frac{1{\cdot}3244 \times 30 \times Q\ d\ (T-t)}{33{,}000\ (459+T)\ (459+t)}$$

and by reducing this becomes

$$f' = \frac{3875{\cdot}872\ C\ (459+t)\ (459+T)}{Q\ d\ (T-t)}$$

from which expression the quantities in column 14 of the table have been calculated.

Notwithstanding the liability of ventilating machines to get out of repair, and their consequent unsuitableness for fiery mines, there may be cases of non-fiery mines, where the saving of tubbing, timber, and ropes, in working shafts, together with a saving of fuel, in probably every instance, to be effected by a machine when compared with a furnace, may justify their adoption as a matter of economy; and in some shallow

mines, where a ventilating furnace has to act under the disadvantage of a short upcast column, if even explosive gas is generated in the mine, it may, perhaps, be best to adopt duplicate ventilating machines in preference to a furnace, even as a matter of safety.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, JUNE 3, 1858, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

The minutes of the Council having been read, Mr. Thos. Braithwaite, Eglington Iron Works, Kilwinning, Ayrshire, was elected a member of the Institute.

The PRESIDENT then said, that at the last meeting they proceeded to a certain extent with the discussion on the Lundhill Colliery Accident, and on the Ventilation of mines generally; and that the questions then under discussion seemed to resolve themselves into two points, viz., The splitting of air;—And the use of regulators in substitution of the use of doors in the distribution of the main currents of air. The Lundhill Colliery, (and the collieries in the Barnsley district generally), were so worked that the air was not more split than once, viz., two currents passing, generally, on the north and south sides of the pit; and working by a system of boards and benks, where each benk was made to communicate in the face with the others alongside of it—the one split of air passing around the south workings, and the other around the north workings, meeting in the centre, and so passing to the upcast pit; thus admitting an uninterrupted communication along the faces of the benks on the south and north sides respectively, and, of course, requiring doors at each of the board-gates to force the main current to the extreme south and north ends of the workings. There were in the Lundhill Colliery seven sets of benks, besides the two levels north and south, requiring a double set of doors in each. When all was right, and admitting that the mode of distributing the air around the workings was to have only two main currents in the pit, and that each

of these currents should be taken to the extremities of the workings first, and then passed around the faces of each series of benks to the main furnace drift; the placing double doors at each of the board-gates completed the system. But there were these disadvantages, that the current of air passing each of the benks in succession, if it was loaded with inflammable air the last benk got the whole of the contaminated or loaded air. Then the tendency of the air being towards the shortest distance to the upcast, the scale of each door in succession would abstract a portion of the air from the extreme workings, and if any of the doors were left (almost, if not quite) open, the whole of the air might pass through such door, and thus abstract the entire current from the in-bye workings. It was well known that, by splitting the air into several currents, a great diminution of resistance was effected, and a much larger quantity of air in the aggregate obtained. The discussion at the previous meeting went to determine if, in such a case as the Lundhill, it might not be advisable to split the air into as many divisions as there were sets of benks and board-gates, viz., into seven divisions, or even more; and supposing, as appeared to be the case at present, 35,000 cubic feet of air was passing around the whole of the benks on the south, and 35,000 cubic feet passing around the benks on the north side per minute, they would have 10,000 cubic feet of air per minute in each benk. By taking the air direct from the main levels up each of the board-gates successively, and so ventilating each set of benks and board-gates with a separate current; and this being done by regulators, the doors in each of the board-gates would be dispensed with, and the tendency or scale of air would then be towards the workings where it was required, and not, as in the present system, towards the upcast and so abstracted from the workings where it was required. Admitting this case to be illustrative of the two systems of ventilation or modes of distributing the air in general, he proposed that they should resume the discussion on those two points, viz., The splitting of the air, and the system of employing regulators instead of doors.

There was one point, however, which they must consider in such discussion, which was this, and which, indeed, involved, likewise, the system of working the coal:—He had pointed out, and the plan would show, that the system of working pursued at Lundhill was, that the benks were worked by the board-gates on each side. When the air was split, and a separate current conveyed up each board-gate, the air of two board-gates would meet in the same benk; it would, therefore, require special

arrangements to equalize the relative quantities of air in each board-gate, as the distances which each current had to travel would be unequal; —and this led him to allude to the discussion that had arisen between Mr. Wales and Mr. Hopton, which, as it bore directly upon this question, he thought there was no impropriety in alluding to. Mr. Hopton, it was well known, had published a Map or Plan showing a mode of ventilating the Lundhill Colliery, by splitting the air into as many divisions as there were benks and board-gates, which he accomplished by regulators; but as it appeared from his map that the air of two of the board-gates passed into one benk, and passed through the same, or only one regulator, although the distances which each current travelled were unequal. Mr. Wales attacked Mr. Hopton, by contending that it was impracticable to produce an equal amount of ventilation or quantity of air in each of the two board-gates, if the two currents terminated in one goaf and were passed through one regulator. Like many such disputes, the subject branched off in the course of discussion into several collateral questions, but the main question was, if it was practicable to work a colliery by benks or long wall, having several board-gates into such benks or long wall, and to split the air, so that each board-gate had a separate current; and that the ventilation could be managed by regulators so as to produce an equal amount of ventilation or current of air up each board-gate, if two or more of the benks or if the long wall ventilated by such currents terminated in one goaf—presuming, (as indeed must be the case practically) that the distances which the air had to travel up each board-gate were unequal. These were all subjects which it was desirable should be discussed before the question of the Lundhill Accident, and the ventilation of mines arising out of such discussion should be terminated. Then there was the separate question as regarded ventilation by regulators, started at the last meeting, viz., how far the ventilation was effected in each way or district ventilated by unequal lengths of currents, by a variation in the aggregate amount of air passing down the pit, or through the regulators. Mr. Atkinson, who was present, having gone into the subject of ventilation in a theoretical point of view very minutely, which was published in their "Transactions," he (the President) asked Mr. Atkinson after the last meeting if he would consider this question, and give the Institute the benefit of such consideration in extension, as it were, of his former paper on the subject, which, he was glad to say, Mr. Atkinson promised to do. That paper, he regretted to

The PRESIDENT said, they were aware that in the Monkwearmouth workings, where the temperature was very great, a current of air was found to pass into the boards along the bottom of the mine, while a counter current passed along the roof; but this was a case where the air was almost stagnant. He did not think such would occur in the case pointed out by Mr. Barkus.

Mr. BARKUS—But the two gases would not be mixed up at once?

The PRESIDENT—He spoke of a current of air, travelling, probably, at the rate of three or four feet per minute.

Mr. BARKUS meant, that at short distances the gases would not be effectually mixed.

Mr. DUNN considered they were losing sight of the real question, viz., as to how they could get the most air into the pit.

Mr. ATKINSON then ably illustrated, by diagrams, what he meant by the ventilating power in the shaft, counterbalancing the disadvantage of the air being brought from the rise to the deeper shaft; and showed, by such diagrams, that the air at the extreme face of the workings would press towards the low level and deeper shaft, rather than towards the rise shaft; and showed, consequently, that a rise shaft would be of no practical benefit, and that it was fallacious to suppose that the sinking of a rise shaft would tend to save life. No doubt, he said, the more shafts there were the greater would be the facilities of escape in case of explosions, if the roads to them, and all the drawing apparatus, were kept in order.

Mr. BARKUS asked, in reference to the explanation given by Mr. Atkinson, if there were no reaction or other circumstances in such a case acting against the ventilating power of the deeper shaft? He knew it might be correct, theoretically, but he would rather have a practical illustration.

The PRESIDENT said, that the general practice of the profession would show, independently of theory, that a deep shaft was better than a shallow one, for the purpose of ventilation; and that the air of rise workings could, without any difficulty, be conveyed down a considerable inclination of seam to a deep shaft, and that such shaft would have a preponderating effect over a pit sunk to the rise.

Mr. BARKUS had no doubt when the seams were nearly level; but, he asked, if an accident was not more likely to arise from working the pillars towards the rise than from working them towards the dip?

Mr. MARLEY said, that before answering the question as to which of

the two shafts the air would press towards, viz., whether to the rise, or to the deep shaft, the President ought first to inform them that the surface level of the two were equal.

The PRESIDENT—That, he took for granted would be assumed by every one present that the surface must be considered as level, and that the increased depth of the lower pit would be equal to the dip of the seam between the two. They might assume that the air would be conveyed horizontally along the face right and left to a centre drift, up which it might be taken to a rise shaft, or down which it might be taken to the dip shaft, then the question was, which of the two shafts would best ventilate the colliery?

Mr. GREENWELL—But suppose they were working the pillars to the rise, then it would be seen they could not clear the goaf of gas with deep shafts, by having a communication only with the lower side of such goaf. If, however, they had a drift from the centre of the goaf to the rise, and a shaft at the end of such drift, they would clear the gas from the goaf.

The PRESIDENT—That could only be done by a drift previously driven to the rise, so that the goaf air would find its way along such drift to the rise pit. If, however, a communication was made between the end of this drift and the deep shaft, the probability was, that the deep shaft would clear the goaf more effectually than the rise shaft.

Mr. REID thought they had strayed from the subject they were discussing. The order of the discussion was, as to whether it was better to ventilate with doors or with regulators. He for one apprehended that doors depended upon every one who passed through them, while the regulators depended upon a select body of men.

The PRESIDENT—If the regulators were once of the proper area, they would require, in his opinion, no looking after, except on extraordinary occasions. He admitted that the discussion was irregular, as the question was, as to whether or not the air could be conducted through the workings by regulators in substitution of doors; but he could not always keep the discussion regular. Reverting to the original question, as to the regulation of the quantity of air when the aggregate quantity was varied:—Suppose there were two ways in a pit, one current double or treble the length of the other, the area of the regulators being apportioned accordingly, and suppose by some accident or variation of atmospheric influence the quantity of air was diminished one half; would the regulators, in this case, require any alteration? or would the same area in the two regulators produce the same relative quantities of air

in each current, the aggregate quantity of air being diminished one half?

Mr. Atkinson—Suppose, a pit had two ways, one, four-times the length of the other; then, suppose, the proportion of air twice as much with the long run as the short one? Then, say, would the short run get a greater proportion of the whole, or would the air be reduced in equal proportions, when the bulk of it was changed?

Mr. Barkus thought, the quantities would go through the regulators in proportion to the area of the apertures. The splitting of air might be carried too far. He, knew of one instance, where the air was entirely stopped in one of the splits, in consequence of a variation of quantity of air by a door being left open.

Mr. Atkinson—But, that would only be a cessation of air in the particular district.

Mr. Barkus—Yes, in one split.

The President—But such an occurrence would be still more fatal, if there were only two currents. In the paper, Mr. Atkinson was going to favour them with, in explanation of the effect of regulators, he, understood, he was prepared to prove, that all circumstances being the same, except in the aggregate quantity of air, and continuing so, the regulators once adjusted, would always send the same relative quantities into the different districts, whatever might be the aggregate quantity of air.

Mr. Atkinson was of opinion, that there were no exceptions, unless the currents of the rise and dip workings were influenced by changes of their temperature. Local circumstances, might vary this to some extent, especially, if the dip and rise of the seam were considerable; but, if they took the air-courses and coal as being horizontal, then, the proportions would hold good, as the regulators being once set, might remain so for ever.

Mr. Greenwell differed from Mr. Atkinson. Suppose, a case, where there were 50 pillars of winning headways, and the stopping was taken out of the first stenting; if the ventilating power was so weak that the whole of the air would pass through the stenting, they would find that very little air would pass into the face of the headways. But, on the other hand, if the ventilating power was greater, then the surplus would pass into the face. If, therefore, a regulator were placed in the first stenting, it would depend entirely upon the ventilating power, whether any air passed into the face or not.

Mr. Dunn to Mr. Atkinson. Did you not say, that, when once the regulators were fixed, they might remain so for ever?

Mr. Atkinson—What he meant, was, that under all the variations of ventilating pressure, the regulators might remain the same.

Mr. Dunn—Then the regulators would only be altered in proportion as the works extended?

Mr. Berkley said that he had made some experiments at Marley Hill Colliery, and found the air continued precisely in the same proportion. When the current became sluggish each split was reduced in proportion, keeping the same relatively, to what it was in the first instance.

Mr. Atkinson—That was a fact in reference to a case when the current became sluggish, which was the point to which Mr. Greenwell alluded.

The President thought it extremely desirable that the members should, before this subject came for discussion in August, make as many experiments as they could, illustrative of the facts in the several cases. There were very few of them who could not make the requisite experiments. The furnace could be put out, or damped, so as to reduce the current as much as each case would allow, and so the question could be submitted to practical experience. These were facts which would be extremely valuable to the Institute, and he hoped the members would carry this out as far as they could.

Mr. Marley asked the President if his opinion would not be reversed in the case of the effect of a dip and rise upcast shaft, if the upcast to the rise was at a different surface level than the upcast to the dip?

The President replied, by saying clearly so, surface level might compensate for the dip or rise of the seam, but the question could not be settled under such a case. To enable the discussion of the question to be proceeded with, they must assume the surface to be level at the top of the two shafts.

Mr. Marley thought it ought to be understood that the surface was level.

The meeting was then adjourned.

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ON THE

PROPORTIONS

IN WHICH

AIR IN MINES DISTRIBUTES ITSELF

OVER SEVERAL SPLITS OR ROUTES, HAVING DIFFERENT LENGTHS, AND OFFERING DIFFERENT RESISTANCES TO CURRENTS OF AIR PASSING THROUGH THEM

ERRATA.

IN PAPER "ON SPLITTING AIR."

In the plan of Crook Bank Colliery Ventilation, introduce **R** to indicate the existence of a regulator in the return air-way of No. 3 split.

Page 168, nineteen lines from the top, for *hypotenuse* read *hypothenuse*.

[illegible] to air currents, before and after some material alteration in the ventilating pressure, or in the gross quantity of air circulating in the unit of time; supposing the air-ways of the different routes or splits, together with any regulators placed in them, to remain unaltered, and in the same condition after the change in the gross quantity of air circulating, as they were before such change.

The writer had previously expressed an opinion to the effect that, except in so far as the gravitation of air of different temperatures and densities, in ascending and descending parts of the air-ways, forming the different splits or routes, might affect the result, air would divide itself over any series of splits in the same *proportions*, whatever might be the general ventilating pressure employed, and the gross quantity of air circulating in the unit of time, provided the air-ways and the regulators of all the splits remained unaltered, while the general ventilating pressure, or the gross quantity of air circulating in the unit of time, became altered in amount. *See "Transactions," Vol. III., page* 205, *and other parts of the same communication.*

If one of two routes or splits ventilated workings lying to the dip of the two ventilating shafts, and the other route or split ventilated workings to the rise of such shafts, and if the average density of the air in the intakes was, in each split, greater than that of their own returns, there would exist, besides the general ventilating pressure, a nearly constant additional pressure in each of the splits, operating in favour of ventilation as regards the dip workings, but operating against the general ventilating pressure as regards the rise workings; and the amounts of the two latter pressures would bear a continually increasing proportion to the general ventilating pressure, and thus produce proportionally increased effects, as the total ventilating pressure and the gross quantity of air circulating became less and less in amount; so that the dip workings would obtain an increasing proportion, and the rise workings a decreasing proportion of the gross quantity of air circulating in the unit of time, as such gross quantity became itself less and less in amount, owing to a reduction of the general ventilating pressure; or, what is the same in effect, to any increasing contraction in the shafts or general airways, where the gross quantity of air circulates in an undivided state.

If the workings, traversed by the splits were all level, or situated in the same horizontal plane, changes of density in the air, as it circulated, would not sensibly affect the proportions in which the air would divide itself, and they would be the same, whatever was the general ventilating pressure, and whatever the gross quantity of air circulating in the unit of time.

If, owing to an admixture of carbonic acid gas the average density of the returns exceeded that of the intakes, the dip workings would have a pressure against, and the rise workings would have a pressure in favour of ventilation, from this source; and consequently the dip workings would obtain a decreasing, and the rise workings an increasing, proportion of the gross quantity of air circulating, as such gross quantity became reduced in amount, owing to any decrease in the general ventilating pressure employed, or owing to any contraction of the shafts or general airways where all the air circulates in one mass or body.

Of course the opposite effects would, in each of the conditions stated, take place on increasing, instead of diminishing the gross quantity of air circulating, while the air-ways forming the splits and the regulators in them remained unaltered.

Every one familiar with the practice of ventilation in this district, is also, probably, just as familiar with certain current expressions, indicating that a short run will take a certain quantity of air, and only leave

the remainder of the gross quantity to divide itself over the other splits, having longer runs, and offering greater resistances to the passage of a given quantity of air in a given time; such as, "if the regulator in the short run were set open the other splits would be laid *dead*;" "the regulator in the short run is as full as she can contain;" &c., and these remarks are made quite irrespective of whether the short run be to the rise or the dip of the pits. It is not intended to question the well known fact, that the less the resistance offered by an air-way of a split, the greater will be the proportion of air that will circulate in that split; but simply to controvert the common opinion that the short run will either take a certain constant quantity of air, and only leave the remainder to divide itself over the longer splits, whatever be the gross quantity of air circulating; or, at any rate, that if the gross quantity of air circulating be reduced, the short run will thereby obtain a larger proportion of such gross quantity than it obtained before such reduction.

The opinion here to be advocated is, that, except in so far as the difference of density in the air, in different parts of the air-ways of different splits, where the course followed by the circulating air may dip or rise, may give rise to discrepancies, air will divide itself in the same proportions over any number of routes or splits, whatever may be the gross quantity of air circulating in the unit of time; and that the discrepancies alluded to may either be such as to increase, or such as to decrease the proportion of the gross quantity of air following the shortest route; owing to a decrease in the gross quantity of air circulating in the unit of time, when such reduction results either from a reduction in the general ventilating pressure, or from a contraction introduced into the shafts, or into any part of the air-ways where the gross quantity of air circulates.

In advocating the position laid down, it is proposed, in the first place, to state one or two general laws of ventilation, and to support their truth by quoting observations or experiments made for a distinct purpose; then to reason from these laws, so established, to the conclusion which it is the object of this paper to maintain; and, finally, to give the results of experiments that have been made to test the conclusion here advocated.

If the two following laws of ventilation be admitted to be true, it follows, by a process of mere reasoning, that air will divide itself over routes or splits in the same proportions, whatever be the gross quantity of air circulating in the unit of time, or whatever be the total general

ventilating pressure; provided only that the air-ways and regulators of the splits remain unaltered, and that there exists no sources of local disturbance, owing to differences of temperature or density, in the different splits, where the air has to ascend or descend either vertically or at an inclination to the horizon:—

1st.—The quantity of air circulating in the unit of time is directly proportional to the square root of the pressure causing it to circulate, when the state of the air-ways, and all other things, remain constant. In other words, the resistance encountered, and, therefore, the pressure required to overcome it, is directly proportional to the square of the quantity of air circulating in the unit of time, through the same unaltered route or series of connected routes, so long as the state of the air-ways and regulators remain unaltered; always supposing that no sources of natural ventilation arise, from differences of density in the air, at different parts of ascending or descending portions of the routes followed by it.

2nd.—When two or more distinct routes are offered to a current of air, at any point, reüniting again at another point, the air will so divide itself over the routes offered to it, as that the actual resistance met with in each route, from the point where the separation takes place till it reaches the point of reünion, shall be the same; or, in other words, the air will follow the route offering the least resistance to it, in all cases; and will not, in any case, pass in a larger proportion than is required to give rise to the same resistance that is encountered in each of the other routes, always reckoning from the point of splitting to the point of reuniting of the different currents; and, presuming that no local pressures arise, in any of the routes, either in favor of, or against the ventilating pressure, from changes of density in the air, in ascending or descending parts of the different routes followed by it.

The following cases are cited as affording practical or experimental evidence of the prevalence of the first of the laws mentioned, viz., that the quantity of air circulating in any mine is directly proportional to the square root of the ventilating pressure, or that the square of the quantity of air is directly proportional to the pressure; the pressure and the resistance are, of course, in all cases equal to each other; if the pressure were at any moment greater than the resistance due to the quantity of air passing, that quantity would become augmented, until the resistance became equal to the pressure, and no further increase of quantity would then take place.

In Professor Phillips's Report, on the Ventilation of Mines and Collieries, presented to both houses of Parliament, in 1850, at page 25, we have the following statements of the ventilation of collieries:—

Names of Collieries.	Means employed to produce Ventilation.	Quantity of air circulating per minute.
		Cubic Feet.
MOORSLEY.....	Furnace alone	25,000
	Jets alone	22,000
	Furnace and Jets	31,000
BELMONT	Furnace alone	44,007
	Jets alone	59,956
	Furnace and Jets.....	71,895
	Engine alone	47,757
	Furnace and Engine	62,652
CASTLE EDEN	Furnace and Jets	46,706
	Furnace alone	42,670
	Jets and Shaft Heat*	35,622
	Shaft Heat alone	30,307

* See Transactions, Vol. I.

Now, if the first law be correct, and really prevails, it follows, that if m represent the height of motive column, or pressure per unit of surface, required to overcome the resistance of the unit of air passing through the mine, in the unit of time, we should have

$$1^2 : m :: Q_1^2 : P_1 \ldots\ldots\ldots\ldots [1]$$

where Q_1 is a new quantity of air passing through the same unaltered mine in the unit of time, and P_1 is the motive column or pressure per unit of surface required to create the ventilation Q_1; and, in like manner, any other quantity Q_2, and corresponding pressure P_2, would enter into a similar proportion; or

$$1^2 : m :: Q_2^2 : P_2 \ldots\ldots\ldots\ldots [2]$$

from whence we have the ventilating pressures $P_1 = m\ Q_1^2$; $P_2 = m\ Q_2^2$, and so on, as due to the different quantities of air circulating in the unit

of time; m being a constant quantity for the same unaltered mine, whatever be the quantity of air circulating in the unit of time; and, therefore, if P_1 and P_2, acting as motive columns, separately produce ventilations represented by Q_1 and Q_2 respectively, then, taking Q_3 to represent a new quantity as due to the united or combined operation of such two forces, we should, by a similar process, have the three following expressions for their separate and joint operation; or the three forces P_1, P_2, and $(P_1 + P_2)$:—

$$\frac{P_1}{m} = Q_1^2 \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

$$\frac{P_2}{m} = Q_2^2 \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

$$\frac{P_1 + P_2}{m} = Q_3^2 \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

and, by adding [3] to [4], we obtain

$$\frac{P_1 + P_2}{m} = Q_1^2 + Q_2^2 = Q_3^2 \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

The form of the last expression, $Q_1^2 + Q_2^2 = Q_3^2$, indicates that if we make the quantities Q_1 and Q_2, due to the separate action of the two ventilating pressures, P_1 and P_2, respectively proportional to the base and perpendicular of any right-angled triangle, then will the quantity Q_3, due to the united action of the same forces, be proportional to the hypotenuse of the same right-angled triangle; and in the same unaltered mine we should have

$$Q_1 = \sqrt{Q_3^2 - Q_2^2} \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

$$Q_2 = \sqrt{Q_3^2 - Q_1^2} \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

$$Q_3 = \sqrt{Q_1^2 + Q_2^2} \ldots\ldots\ldots\ldots\ldots\ldots [8]$$

The three equations [6], [7], and [8], it has been shown, arise as a direct consequence of the law of the quantities being proportional to the square roots of the pressures due to them, in the same unaltered mine; and we will now proceed to ascertain how far such law actually prevails, by applying them to the cases given in Professor Phillips's Report, as before alluded to.

Names of Collieries.	Application of Formulæ [6], [7], and [8].	Quantities calculated by Formulæ [6], [7], and [8].	Actual Quantities observed.	Remarks.
Moorsley	$\sqrt{\text{Furnace } 25{,}000^2 + \text{Jets. } 22{,}000^2}$ ..... =	Furnace and Jets. 33,301	31,000	Nearly 7 per cent. difference.
Belmont	$\sqrt{\text{Furnace } 44{,}007^2 + \text{Jets. } 59{,}965^2}$ ..... =	Furnace and Jets. 74,373	71,895	Nearly 3½ per cent. difference.
Ditto	$\sqrt{\text{Furnace } 44{,}007^2 + \text{Engine. } 47{,}757^2}$ ..... =	Furnace and Engine. 64,941	62,652	About 3½ per cent. difference.
Castle Eden..	$\sqrt{\text{Furnace and Jets. } 46{,}706^2 - \text{Furnace. } 42{,}670^2}$ ... =	Jets alone. 18,993	Not observed.	The quantity calculated from two sets of data, as being due to steam jets, differ less than 1½ per cent. from each other; the real quantity was not observed.
Ditto	$\sqrt{\text{Shaft Heat and Jets. } 35{,}622^2 - \text{Shaft Heat. } 30{,}307^2}$ .. =	Jets alone. 18,719	Not observed.	

The annexed diagrams exhibit these cases graphically.

The slight discrepancies between the quantities observed, and those calculated on the law of the squares of the quantities being proportional to the pressures or resistances, are no more than might have been anticipated, and are, probably, due in part to errors of observation, and in part to no allowances having been made in the calculations for any extra resistance, due to the more expanded volume of a given weight of air in the upcast shaft, when the two ventilating powers act jointly, as compared with its volume when either of them act separately.

Again, in the case of Brunton's ventilating fan, as applied at Gelly Gare colliery, it was stated in evidence before a parliamentary committee, in 1849, that the quantity of air discharged was directly proportional to the number of revolutions made by the fan; and, hence, if the pressure or water-gauge were proportional to the square of the quantity of air circulating in the unit of time, it follows that the revolutions in the unit of time should be proportional to the square root of the water-gauge indicating the resistance or ventilating pressure.

The following observations were given in evidence in the case alluded to,—

No.	OBSERVATIONS.	
	Water Gauge.	Revolutions Per Minute.
	Inches.	
1	0·55	48
2	2·10	93
3	2·50	100

Taking No. 2 observation as a datum, and calculating, on the principle named, to find the revolutions due to the observed water-gauge, in each of the other cases, we obtain the proportions,

As $\sqrt{2{\cdot}10}$ (In.) : $\sqrt{0{\cdot}55}$ (In.) :: 93 (Revol's.) : 47·59 (Revol's.), in No. 1 case, where 48 revolutions per minute were observed; which is not one per cent. different from the calculated quantity; and, in No. 3 case,

As $\sqrt{2{\cdot}10}$ (In.) : $\sqrt{2{\cdot}50}$ (In.) :: 93 (Revol's.) : 101·47 (Revol's.), a number greater than the observed number of revolutions by only 1½ per cent.; errors so small as to be readily accounted for, by the difficulties of taking accurate observations.

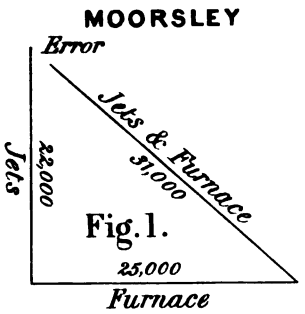

Fig. 1.

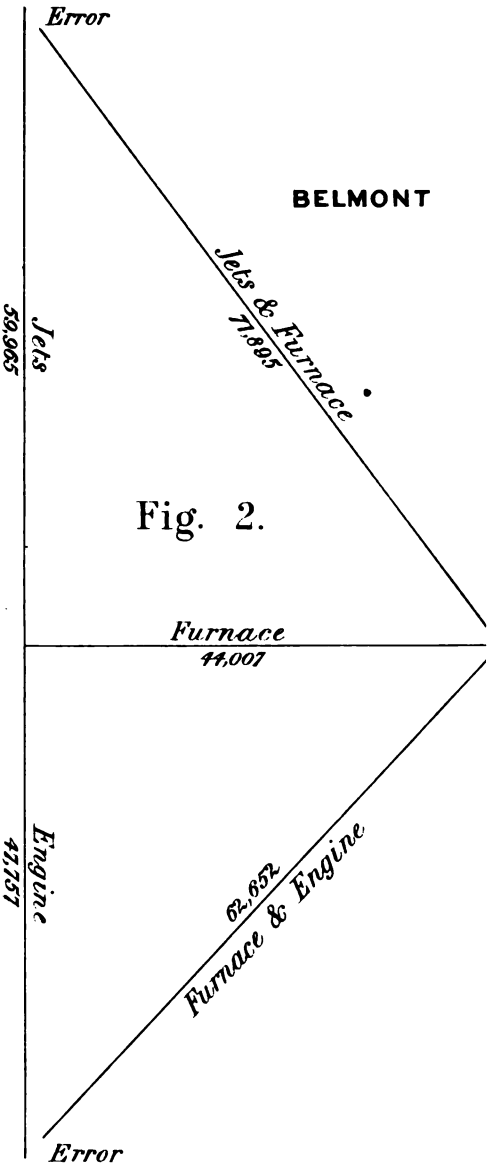

Fig. 2.

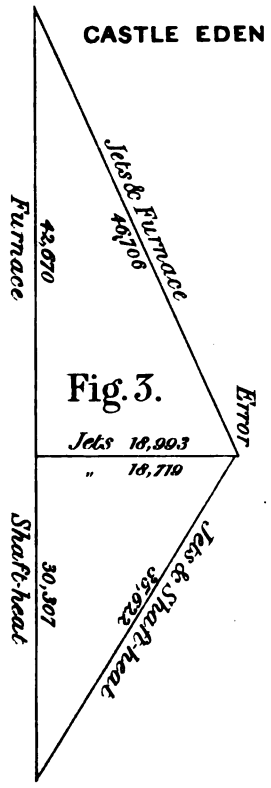

Fig. 3.

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The experiments of Girard, Péclet, Daubuisson, and others, on the flow of air through pipes, flues, and chimneys, all agree in leading to the same general conclusion, that the resistance met with by air, and, consequently, also the pressure per unit of surface required to overcome it, is, *cæteris paribus*, sensibly proportional to the square of the quantity of air passing in the unit of time, through the same unaltered channel; and hence this law, it is submitted, may be held to be established, both for uniform pipes and also for the air-ways of mines, notwithstanding the great irregularities in their sections, and, in many cases, the existence of regulators or artificial contractions in them. The small discrepancies in the cases of mines, there is little doubt, may be referred to the causes already assigned.

But for the slight discrepancies—arising from the increased resistances encountered by a given weight of air passing through a mine when an energetic ventilation is in existence, compared with that encountered when only a feeble ventilation is in operation, owing to the more expanded state of the air in the former than in the latter case—the law of the squares of the quantities of air circulated in the unit of time, being proportional to the pressure putting them into circulation in the same mine, coupled with the fact that the powers creating ventilation are proportional to the product of the quantities of air circulated in the same mine in the unit of time, multiplied by the ventilating pressures required to put them into circulation, would lead to the following conclusions and formulæ, which, in practice, will be found to be very near the truth, except under extraordinary circumstances.

If the areas of two squares, A and B, Fig 4, be made respectively proportional to two ventilating pressures, p_1 and p_2, employed at different times at the same mine, then will the area of a third square, C, having the length of its side proportional to the hypothenuse of a right-angled triangle, the base of which is formed by the side of the square A, and the perpendicular by the side of the square B, be similarly proportional to the sum of such two pressures, or to $p_1 + p_2$; and if q_1 represent the quantity of air put into circulation in the unit of time by p_1; and q_2 the quantity circulated by the pressure p_2; and if Q represent the quantity of air circulated in the unit of time by a pressure equal to the sum $p_1 + p_2$ of these two pressures, in the same mine, then will these quantities, q_1, q_2, and Q, be respectively proportional to lengths of the base, perpendicular, and hypothenuse of the same right-angled triangle.

And the contents of the cubes A, B, and C, having the areas of their

respective sides proportional to the pressures p_1, p_2, and $p_1 + p_2$; and the lengths of their respective edges, proportional to the quantities q_1, q_2, and Q, (the latter quantities being respectively proportional to the base, perpendicular, and hypothenuse of the right-angled triangle,) will be proportional to the powers h_1, h_2, and H, required to circulate the quantities q_1, q_2, and Q, in the unit of time, under the pressures proportional to p_1, p_2, and $p_1 + p_2$ respectively, in the same mine.

Now, letting B = the base, P = the perpendicular, and H = the hypothenuse of such right-angled triangle, the laws just recited lead to the proportions.

$$\text{As } B : q_1 :: P : q_2 :: H : Q = \sqrt{q_1^2 + q_2^2}$$
$$\text{,, } B^2 : p_1 :: P^2 : p_2 :: H^2 : p_1 + p_2$$
$$\text{,, } B^3 : h_1 :: P^3 : h_2 :: H^3 : H = (h^{2/3} + h^{2/3})^{3/2}$$

From which are deduced the following equations* :—

$$q_1 = \frac{B}{P} q_2 = q_2 \sqrt{\frac{p_1}{p_2}} = q_2 \sqrt[3]{\frac{h_1}{h_2}} = \frac{B}{H} Q = Q \sqrt{\frac{p_1}{p_1 + p_2}} = Q \sqrt[3]{\frac{h_1}{H}}$$

$$q_2 = \frac{P}{B} q_1 = q_1 \sqrt{\frac{p_2}{p_1}} = q_1 \sqrt[3]{\frac{h_2}{h_1}} = \frac{P}{H} Q = Q \sqrt{\frac{p_2}{p_1 + p_2}} = Q \sqrt[3]{\frac{h_2}{H}}$$

$$Q = \frac{H}{B} q_1 = q_1 \sqrt{\frac{p_1 + p_2}{p_1}} = q_1 \sqrt[3]{\frac{H}{h_1}} = \frac{H}{P} q_2 = q_2 \sqrt{\frac{p_1 + p_2}{p_2}} = q_2 \sqrt[3]{\frac{H}{h_2}}$$

$$p_1 = \left(\frac{B}{P}\right)^2 p_2 = p_2 \left(\frac{q_1}{q_2}\right)^2 = p_2 \left(\frac{h_1}{h_2}\right)^{2/3} = \left(\frac{B}{H}\right)^2 (p_1 + p_2) = \left(\frac{q_1}{Q}\right)^2 (p_1 + p_2) = \left(\frac{h_1}{H}\right)^{2/3} (p_1 + p_2$$

$$p_2 = \left(\frac{P}{B}\right)^2 p_1 = \left(\frac{q_2}{q_1}\right)^2 p_1 = \left(\frac{h_2}{h_1}\right)^{2/3} p_1 = \left(\frac{P}{H}\right)^2 (p_1 + p_2) = \left(\frac{q_2}{Q}\right)^2 (p_1 + p_2) = \left(\frac{h_2}{H}\right)^{2/3} (p_1 + p_2$$

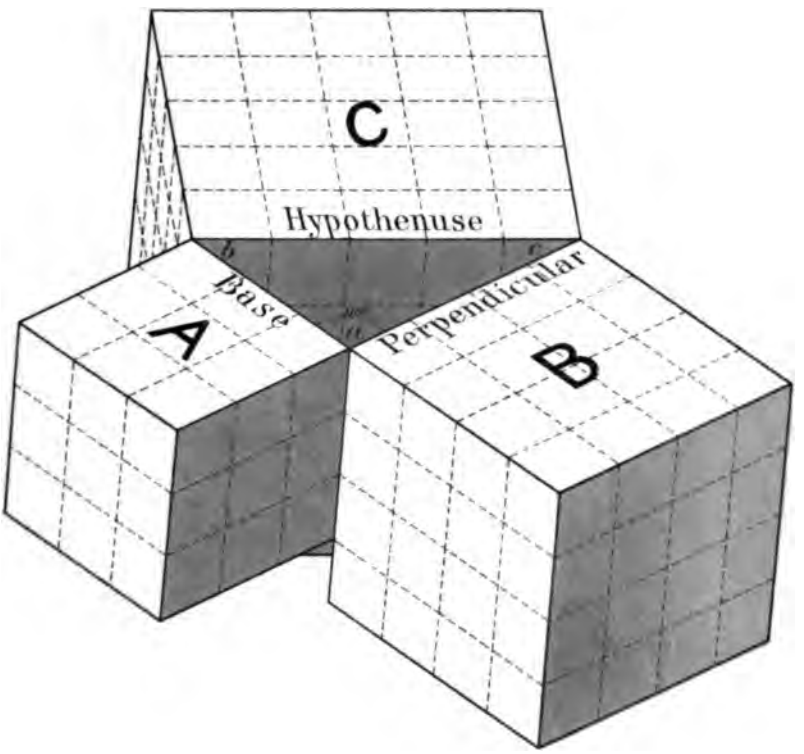
$$p_1 + p_2 = \left(\frac{H}{B}\right)^2 p_1 = \left(\frac{Q}{q_1}\right)^2 p_1 = \left(\frac{H}{h_1}\right)^{2/3} p_1 = \left(\frac{H}{P}\right)^2 p_2 = \left(\frac{Q}{q_2}\right)^2 p_2 = \left(\frac{H}{h_2}\right)^{2/3} p_2$$

$$h_1 = \left(\frac{B}{P}\right)^3 h_2 = h_2 \left(\frac{q_1}{q_2}\right)^3 = h_2 \left(\frac{p_1}{p_2}\right)^{3/2} = \left(\frac{B}{H}\right)^3 H = H \left(\frac{q_1}{Q}\right)^3 = H \left(\frac{p_1}{p_1 + p_2}\right)^{3/2}$$

$$h_2 = \left(\frac{P}{B}\right)^3 h_1 = h_1 \left(\frac{q_2}{q_1}\right)^3 = h_1 \left(\frac{p_2}{p_1}\right)^{3/2} = \left(\frac{P}{H}\right)^3 H = H \left(\frac{q_2}{Q}\right)^3 = H \left(\frac{p_2}{p_1 + p_2}\right)^{3/2}$$

$$H = \left(\frac{H}{B}\right)^3 h_1 = h_1 \left(\frac{Q}{q_1}\right)^3 = h_1 \left(\frac{p_1 + p_2}{p_1}\right)^{3/2} = \left(\frac{H}{P}\right)^3 h_2 = h_2 \left(\frac{Q}{q_2}\right)^3 = h_2 \left(\frac{p_1 + p_2}{p_2}\right)^{3/2}$$

* The equations which contain only q_1, q_2, p_1, p_2, h_1 and h_2, or their functions, are also applicable to any two amounts of ventilation, and their corresponding pressures and powers, in the same mine.



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The truth of all or any of which equations may be tested by selecting the values of the literal symbols contained in them, from the following table, which is constructed on the principles that have been explained as the basis of the formulæ presented.

Quantities of Air circulated in the unit of time or numbers proportional to them.	Pressures required to circulate the quantities, or numbers proportional to such pressures.	Pressures required to circulate the quantities of air, or numbers proportional to such powers.
$q_1 = B = 3$	$B^2 = 9$	$q_1 \times B^2 = 27$
$q_2 = P = 4$	$P^2 = 16$	$q_2 \times P^2 = 64$
$Q = H = 5$	$(9 + 16) = H^2 = 25$	$Q \times H^2 = 125$

The general principles just alluded to are, as has been stated, not rigidly true, under all conditions, although, in most cases, in practice they will hold nearly true.

The more energetic the ventilation of a mine, if ventilated by exhaustion, whether produced by furnace action or by ventilating machines, the more expanded becomes the volume of a given quantity of air, and hence arises an increased resistance directly proportional to the degree of expansion; and the power required is further enhanced by the increased velocity due to this increased expansion; and these circumstances, so far as their effects extend, render the pressures and powers required for increased quantities, somewhat greater than are indicated by the principles stated. If local pressures arise in the different splits of a mine, either acting in aid of, or against the general ventilating pressure, their effects bear a decreasing proportion to the ventilating pressure employed, as it becomes increased in amount; and produce, therefore, proportionately diminished effects; so that the prevalence of such pressures in a mine is another circumstance preventing the laws stated from holding accurately true, and the discrepancies will, of course, be more or less considerable as these disturbing causes happen to be greater or less in amount in any mine.

The second principle or general law of ventilation which has been advanced as (in conjunction with that already discussed) leading to the conclusion that air will split or divide itself in the same proportions, whatever be the amount of ventilating pressure and the gross quantity of air circulating in the unit of time, in the same unaltered air-ways, (provided the workings are either situated in the same horizontal plane, or that no differences of density exist in the air in ascending or descend-

ing parts of the air-ways, owing to the admixture of gases or to variations in the temperature of the air in different parts of the air-ways,) is of so simple a character as to be almost, if not quite, self-evident. If, for instance, at any point in a main air-way several splits are formed, it is evident that the air, on entering each of these splits, has one and the same pressure and density; and whatever be the lengths, sections, ascents, or descents, and whatever be the nature or dimensions of any contractions or regulators in all or any of the routes pursued by the splits, still, if they all reunite in one common return, they must, at the point of reünion, each have, in like manner, one common pressure, seeing that their union forms but one single aeriform medium after they are again united; and, therefore, each must, on the whole, have encountered precisely the same amount of resistance, while in the form of separate splits, reckoning such resistances as measured by the expenditure of motive column or pressure on the unit of surface; and in order that this equality may prevail amongst such resistances, encountered by the different splits, the air must, of necessity, divide itself over them in the particular proportions required to lead to this result, because all matter moves under the application of force or pressure, when not resisted by an equal opposing force; and where opposing forces operate on the same matter, then the greater the excess of the moving, over any opposing, force, in any particular direction, the quicker the matter moves in that particular direction; and as, in the case in hand, the moving force is the same in every direction, or over each split, the air must naturally so distribute itself in the various splits, that the resistance or opposing force encountered in each split will also be of equal amount.

On the principles stated, it is evident, that if, by using a water-gauge or other suitable means, we ascertain the motive column or pressure per unit of surface, expended on the resistances encountered in any of such splits or divided air-ways, by an ascertained quantity of air passing through them in the unit of time, we can then, by the 1st law, (the squares of the quantities being proportional to the resistances) determine the pressure per unit of surface, or the height of motive column necessary to overcome the resistances of the same passages or air-ways, due to any other quantity of air in the unit of time.

For instance, if, when Q represents the actual quantity of air circulating in any air-way in the unit of time, we observe, by the water-gauge or other suitable means, that P is the resistance or motive column, we find that if only the unit of quantity passed in the unit of time

$$Q^2 : P :: 1^2 : m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [9]$$

where m is the motive column or pressure per unit of surface required to overcome the resistance. And this unit of quantity may evidently be of any magnitude whatever, as a cubic foot, a cubic yard, 100 cubic feet, or 1,000 cubic feet, provided only that Q itself be of the same denomination; as in cubic feet, cubic yards, hundreds of cubic feet, or thousands of cubic feet, or whatever is assumed as the unit of quantity. From [9] we also obtain

$$m = \frac{P}{Q^2} \quad \ldots\ldots [10]$$

$$Q = \sqrt{\frac{P}{m}} \quad \ldots\ldots [11]$$

$$P = Q^2 m \quad \ldots\ldots [12]$$

From [10] we can determine the pressure per unit of surface, or, in other words, the motive column necessary to overcome the resistances of any such air-way, or any part of such air-way, when only the unit of quantity (in which Q is reckoned) is passing through it in the unit of time; provided we have first observed, by the water-gauge or other proper means, the pressure, P, required to overcome the resistance of the quantity, Q, passing through it in the unit of time.

By [11] we can determine the quantity of air, Q, which would circulate in the unit of time under any assumed pressure, P; provided we have, by the means already mentioned, first found the specific resistance, m, of the air-way; or, in other words, the motive column or pressure per unit of surface, due to the passage of the unit of quantity (in which Q itself is reckoned) in the unit of time.

And by [12] we can ascertain the height of the motive column or pressure per unit of surface, P, required to force any assumed quantity, Q, through any such air-way, in the unit of time; provided we have first found the specific resistance, m, of the air-way.

And here it may be observed that the specific resistance, m, may refer either to any one of a series of splits, or it may refer to the united action of the entire series or any number of them, provided only that the quantity of air, Q, be taken as being equal to that circulating through such single air-way, or such series or part of a series of splits in the unit of time, by means of the pressure, P, observed to prevail at the time of ascertaining the quantity of air, Q; in the case of Q representing the entire quantity of air distributed over a series of connected splits or routes, m, of course, does not represent the specific resistance of any one of such

splits or routes, but that of an air-way which would transmit, under the general pressure, P, exactly the same quantity of air that is transmitted by the united operation of the entire series of splits; and all the formulæ given would hold equally true, whether applied to any single split of the series, or to all, or any number of them, considered as acting jointly in aid of each other.

The mode of finding the specific resistance of any series of connected routes or splits, considered as acting in aid of each other, or forming a general passage for air, when we know the specific resistance of each route, and their relative positions, is given at page 120, &c., vol. III., of "Transactions," as founded on the two general laws adopted in this paper, and, therefore, need not be repeated here.

We may now proceed to show that if the resistance or ventilating pressure due to air circulating through any channel, or any series of channels, considered as acting in aid of each other, is proportional to the square of the quantity circulating in a given time; and if when a series of channels offer themselves to air under pressure, it will so distribute itself amongst them that each split will encounter the same amount of actual resistance as the others, reckoning such resistances, in each case, from the point of separation or splitting, to the point of the reünion of the same splits; then, as a matter of course, air will divide itself over any series of splits or channels in exactly the same proportions, whatever may be the general ventilating pressure employed, and whatever may be the gross quantity of air circulating in the unit of time; always presuming that only the same general ventilating pressure is applied to the whole of the splits, and that no peculiar forces or resistances exist or arise in the different splits, from changes of density in the air in ascending and descending parts of such splits, and that the state of the air-ways, and all contractions or regulators placed in them, remain in the same unaltered state, after any alteration is made in the gross quantity of air circulating in the unit of time; whether such alteration in the gross quantity of air circulating in the unit of time be affected by reducing the general ventilating pressure; as, by putting a furnace out; or by introducing contractions or regulators into the shafts, or any general air-ways, where the whole of the air happens to be confined to one channel, before reaching, or after passing the part where the splits prevail. This conclusion is established by the following reasoning.

On the principles stated, if Q be the gross quantity of air circulating through a mine, in which the air is divided into any number of splits

whatever, when the general ventilating pressure per unit of surface, expended on the resistances, in that part of the general air-ways of the mine over which the splits prevail, is P, as observed by a water-gauge, or corrected barometrical observations; and, if M be the specific resistance of the splits, considered as acting jointly, or in aid of each other, that is to say, the actual resistance or pressure per unit of surface, due to the passage of the unit of quantity through the mine, in the unit of time, and, therefore, distributed over the whole of the splits; we have the equation,

$$P = Q^2 M \ldots\ldots\ldots\ldots\ldots\ldots\ldots [13]$$

and reckoning all or any splits from their point of separation, to the point where they again unite, on the same principles we have

$$P = Q^2 M = q_1^2 m_1 = q_2^2 m_2 = q_3^2 m_3 = q_4^2 m_4 = \&c. \ldots\ldots\ldots [14]$$

where q_1, q_2, q_3, q_4, &c., represent the quantities of air in the different splits, referred to by the numbers, and m_1, m_2, m_3, m_4, &c., the specific resistances due to the splits, as also referred to by the corresponding numbers; and since m_1, m_2, m_3, m_4, &c., are simply the pressures per unit of surface, or the motive columns required to circulate the unit of quantity in the unit of time, through the respective splits referred to by the numbers 1, 2, 3, 4, &c., attached to the literal symbols, they are all constant quantities, so long as the air-ways or splits to which they refer, remain unaltered, and hence it follows, from the nature of the equations,

$$P = M Q^2 = m_1 q_1^2 = m_2 q_2^2 = m_3 q_3^2 = m_4 q_4^2 = \&c.; \ldots [15]$$

that Q^2, q_1^2, q_2^2, q_3^2, q_4^2, &c., always assume values directly proportional to the value assumed by P; otherwise, since by extracting the square root of [14] we obtain

$$\sqrt{P} = \sqrt{M}\, Q = \sqrt{m_1}\, q_1 = \sqrt{m_2}\, q_2 = \sqrt{m_3}\, q_3 = \sqrt{m_4}\, q_4 \ldots [16]$$

where

$\sqrt{m}$, $\sqrt{m_1}$, $\sqrt{m_2}$, $\sqrt{m_3}$, $\sqrt{m_4}$, &c., are all constant quantities, it necessarily follows that Q, q_1, q_2, q_3, q_4, &c., must all vary in the same proportion that $\sqrt{P}$ varies, and, therefore, will always bear the same proportions to each other, whatever may be the value assumed by $\sqrt{P}$; in other words, since not only the gross quantity Q, circulating through all the splits, considered jointly, but also the separate quantities in each of the splits, vary in the same proportion that the square root of the motive column, or pressure per unit of surface ($\sqrt{P}$) varies, whatever value may be assumed by the square root of the motive column, or pres-

sure per unit of surface $\sqrt{P}$, it follows that the quantities of air in each of the splits q_1, q_2, q_3, q_4, &c., will vary in the same ratio or proportion that the whole quantity Q varies, and also in the same proportion as each other; always presuming the air-ways in the various splits to be situated in the same horizontal plane, or that changes of density in the air in the ascending and descending parts of the various splits do not give rise to disturbing pressures, either aiding or abstracting from the general ventilating pressure P, due to the resistances in the parts of the mine where the splits prevail,—this being the conclusion which it was, in the outset, proposed to establish;—and if we admit the two laws to prevail, which were adopted as premises in an earlier part of this paper, it seems to be utterly impossible to deny the above conclusion, seeing that it has been drawn solely from them, as a basis.

Let us next see the result of applying the formula, deduced from the two laws of ventilation, on which the subject of this communication depends, to the case of a supposed mine, when different amounts of ventilating pressure are employed to create ventilation; and afterwards suppose the same mine, but having the mode of splitting the air altered, to have the same series of ventilating pressure applied to it; and, if the result in both cases, confirms the general conclusion, to the effect that, (with the exceptions so often alluded to) air will divide itself always in the same proportions, in the same unaltered mine, whatever may be the gross quantity of air circulating in it, or whatever the amount of the ventilating pressure employed, and into whatever number or lengths of splits it may be divided; we may safely conclude, that such would be the result in practice; or, on the other hand, that the two general laws, on which we have based our conclusion, do not really hold good in practice.

Suppose a mine having two splits of air only, one offering five times the amount of resistance offered by the other, to the passage of equal quantities of air through them in a given time; that is to say, one split or route having five times the specific resistance of the other; and suppose that, with the air-ways so divided, the ventilating pressure required to circulate one hundred thousands of cubic feet of air per minute (adopting 1,000 cubic feet as unit of quantity of air) was 144 feet of air column, and that the specific resistance of the shafts and undivided air-ways near them was ·0012; that is, the air column required to circulate the unit of quantity (1,000 cubic feet) per minute, through such shafts and undivided air-ways near them.

Then by [10] the total specific resistance of the shafts and mine as divided is $\frac{144}{100^2 \cdot 000} = \cdot 0144$, and deducting the specific resistances of the undivided air-ways and shafts from this, gives $\cdot 0144 - \cdot 0012 = \cdot 0132$ as the specific resistance due to the two splits acting in aid of each other.

Now, since the total specific resistance of that part of the mine over which the splits prevail, when they are considered as a general passage, or each acting in aid of the other in transmitting air, is ·0132, and since only two routes or splits are here supposed to exist, they must, of course, separate and reünite at the same points, and, therefore, the actual resistances must be of equal amount in each of the two splits; so that if q_1 represent the quantity of air in the longest split, and q_2 that in the shortest, when the total quantity or sum of the two is represented by Q, and the specific resistances of the separate splits by m_1 and m_2, we have the equations

$$q_1^2 m_1 = q_2^2 m_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [17]$$

$$m_1 = 5\, m_2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [18]$$

$$q_1 + q_2 = Q \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [19]$$

Substituting the value of m_1 in [18], in equation [17] we have

$$5\, m_2\, q_1^2 = m_2\, q_2^2$$

$$\therefore\ 5\, q_1^2 = q_2^2 \text{ and } q_2 = \sqrt{5}\, q_1$$

and by substituting this value of q_2 in [19] we obtain

$$(1 + \sqrt{5})\, q_1 = Q$$

or $q_1 = \frac{Q}{1 + \sqrt{5}} = \frac{100 \cdot 000}{3 \cdot 236068} = 30 \cdot 902$ the quantity of air in the split of which the specific resistance is m_1.

And since $Q = 100 \cdot 000$, by [19] we have

$q_2 = 100 \cdot 000 - 30 \cdot 902 = 69 \cdot 098$ the quantity of air due to the split of which m_2 is the specific resistance.

But since the assumed specific resistance of the splits, acting in aid of each other, is ·0132, and the gross quantity of air per minute 100·000, the actual resistance in the divided part of the mine is $Q^2 \cdot 0132$, or $100^2 \times \cdot 0132$, and is the same in each of the two splits, seeing that they of necessity separate and reünite at the same points, so that

$$Q^2 M = q_1^2 m_1 = q_2^2 m_2 \ldots\ldots\ldots\ldots\ldots\ldots [20]$$

where $M = \cdot 0132$ the specific resistance of the splits acting jointly, and hence

$$m_1 = \left(\frac{Q}{q_1}\right)^2 M \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [21]$$

$$m_2 = \left(\frac{Q}{q_2}\right)^2 M \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [22]$$

Now by (21) $$m_1 = \left(\frac{100{\cdot}000}{30{\cdot}902}\right)^2 {\cdot}0132 = {\cdot}138{,}235$$

and by (22) $$m_2 = \left(\frac{100{\cdot}000}{69{\cdot}098}\right)^2 {\cdot}0132 = {\cdot}027{,}647$$

The expenditure of ventilating pressure, per unit of surface, or of motive column, being equal to the square of the quantity of air circulating in the unit of time, multiplied by the specific resistance of the passage through which it circulates, we have, in this instance,

$100^2{\cdot}000 \times {\cdot}0012 = 12$ feet of air column due to the actual resistances of the shafts and air-ways near to them, where the air is not split.

Also, $30{\cdot}902^2 \times {\cdot}138235 = 132$ feet of air or motive column,

and $69{\cdot}098^2 \times {\cdot}027647 = 132$ do.,

so that 132 feet of air column is expended on the resistances of the air-ways over which the splits prevail.

If in the same mine, with the air divided in the same manner, we presume that instead of 144 feet of air column, only 36 feet of air column is employed, then by a precisely similar mode of calculation we shall obtain the following results:—

Total quantity of air circulating, 50 thousands of cubic feet per minute.

Expenditure of pressure in head of air column, on the shafts, 3 feet, and on the splits 33 feet.

Air circulating, in the long split 15·451, and in the short one 34·549 thousands of cubic feet per minute. The specific resistances in all cases, will, of course, remain unaltered.

Then, if we once more presume the ventilating pressure employed to be reduced to only 9 feet of air column, while the mode of splitting the air, and the state of the air-ways, and any regulators in them, remain the same, a similar mode of calculating leads to the following results.

The total quantity of air circulating per minute, is 25·000 thousands of cubic feet per minute.

The expenditure of pressure per unit of surface on the shaft resistances, is 0·75 foot of air column; and on the divided part of the air-ways, it is 8·25 feet of air column.

The air circulating, in the longest split, is 7·7255; and, that in the short one, 17·2745 thousands of cubic feet per minute. The specific resistances, of course, remain the same as before.

If we next conceive the same mine, instead of being divided into only two splits, to become by a "*change of air*" divided into three splits, having their specific resistances in the ratio of 3, 2, and 1, respectively; and, if we presume such splits to separate and reünite at the same points, and then if we proceed by a mode of calculation, exactly analogous to that already adopted, we find the results which are embodied in the following table:—the ventilating pressures being taken at the same amounts in the three cases given under the new arrangement of splitting the air, that they were taken under the first supposition as to the mode of splitting the air.

Total Height of Motive Air Column.	Total Quantity of Air circulated per Minute.	Specific Resistances.						Expenditure of Pressure or Motive Air Column.			Quantities of Air put into Circulation.				
		Shafts and Undivided Airways near to them.	No. 1 Split.	No. 2 Split.	No. 3 Split.	All the Splits acting jointly.	Total of Shafts and Workings.	On the Shafts and Undivided Airways.	On the Splits acting jointly.	Total Air Column.	No. 1 Split.	No. 2 Split.	No. 3 Split.	Total.	
When the air is divided into two splits, having their specific resistances ·138235 and ·027647 in the ratio of 5 to 1.															
			5	1											
144	100·000	·0012	·138235	·027647	..	·0132	·0144	12	132	144	30·902	69·098	..	100·000	When the divisible airways are in two splits, the specific resistances being as 5 to 1.
36	50·000	·0012	·138235	·027647	..	·0132	·0144	3	33	36	15·451	34·549	..	50·000	
9	25 000	·0012	·138235	·027647	..	·0132	·0144	0·75	8·25	9	7·7255	17·2745	..	25·000	
When the air is divided into three splits, having their specific resistances ·082941, ·055294, and ·027647 in the ratios of 3, 2, and 1 respectively.															
			3	2	1										
144	148·869	·0012	·082941	·055294	·027647	·0052978	·0064978	26·59	117·41	144	37·623	46·079	65·167	148 869	When the divisible airways are in three splits, the specific resistances being in the ratios of 3, 2, and 1 respectively.
36	74·434	·0012	·082941	·055294	·027647	·0052978	·0064978	6 65	29·35	36	18·8115	23·0395	32·5830	74·434	
9	37·217	·0012	·082941	·055294	·027647	·0052978	0064978	1·66	7·34	9	9·4057	11·5197	16·2916	37·217	

An examination of the results of these calculations, as tabulated, shews that under each of the two modes of splitting the air, each of the splits becomes reduced, successively, to one-half and to one-quarter of their original amounts, as the gross quantity of air put into circulation in the unit of time is reduced, in the same proportions; confirming the correctness of the conclusions arrived at, and leaving nothing in a doubtful or disputable state but the premises themselves; that is to say, the laws stated in the outset, as the basis for the reasoning which has conducted to the conclusion. It is, therefore, submitted, that unless the laws in question can be proved to be at variance with practical results, the conclusion is incontrovertible.

It was intended to have appended the results of a few experiments on the point here under discussion, but for want of time and favorable opportunities for making them, only the following two are at present submitted. These were made by Mr. Berkley, in consequence of the difference of opinion that gave rise to this communication, and have been kindly handed over by that gentleman, for insertion.

The experiments were made at Crook Bank Colliery, where the rise is only about 1 in 144, westward; so that any difference of temperature as giving rise to differences of density between the intakes and returns, may be neglected without sensible error. The intake temperature was observed at 51½°, and that of the return at 55°.

The annexed sketch will convey a general idea of the position of the pits and workings.

	Average Area. Sup. Feet.	Distance in Feet.	Time in Seconds.	Total Quantity of Air per Minute observed. Cubic Feet.
Main Air-way at B on Plan....	27	60	15	6,480
In No. 1 Split at C on Plan ...	30·8	60	66	1,680
In No. 2 „ D „ ...	28·7	48	39	2,119
In No. 3 „ E „ ...	33·8	60	68	1,789
Loss by leakage	....	..	..	892
				6,480

For the purpose of altering the gross quantity of air circulating in

the unit of time, the furnace doors at A on the plan were partially opened, and the following observations were then taken :—

	Area.	Distance.	Time.	Quantities.
Main Air-way at B on Plan	27	60	28	3,471
In No. 1 Split at C on Plan ...	30·8	60	123	901
In No. 2 „ D „ ...	28·7	48	77	1,074
In No. 3 „ E „ ...	33·8	60	121	1,006
Loss by leakage	....	..	..	490
				3,471

But had the quantities in the latter case been exactly proportional to the quantities in the same splits, when the greater gross quantity of air per minute was in circulation, they would have been—

In No. 1 Split as	6,480 : 3,471	:: 1,680	:	900
„ No. 2 „		:: 2,119	:	1,135
„ No. 3 „		:: 1,789	:	958
By leakage		:: 892	:	478
				3,471

After the foregoing set of experiments were made, some of the regulators in the splits were altered, and an increased quantity of air circulated, and the following observations taken :—

	Average Area, Sup. Feet.	Distance, Feet.	Time, Seconds.	Total quantity of air per minute, Cubic Feet.
Main Air-way at B on Plan ..	27	60	7	13,886
No. 1 Split at C „ ..	30·8	60	25½	4,348
No. 2 „ D „ ..	28·7	48	19	4,350
No. 3 „ E „ ..	33·8	60	30¾	3,957
Loss by leakage	....	....	....	1,231
				13,886

The furnace doors at A on plan, were partially opened, and the following observations made:—

	Area.	Distance.	Time.	Quantities.
Main Air-way at B on Plan ..	27	60	10	9,720
No. 1 Split at C „ ..	30·8	60	35¾	3,102
No. 2 „ D „ ..	28·7	48	27½	3,024
No. 3 „ E „ ..	33·8	60	44¾	2,719
Loss by Leakage	....	....	....	875
				9,720

If, however, the air had divided itself in the same proportions in the latter case as in the former, the quantities would have been—

In No. 1 Split as 13,886 : 9,720 :: 4,348 : 3,043
„ No. 2 „ :: 4,350 : 3,045
„ No. 3 „ :: 3,957 : 2,770
By leakage :: 1,231 : 862
—— 9,720 Total.

The results of observations in the foregoing experiments are compared, in the following table, with the quantities which, on the principle advocated in this communication, ought to have prevailed:—

In the first set of Experiments.	Total length of Splits.	Observed Quantities.	Quantities calculated.	Errors. Cubic Feet.	Errors. Per Cent.
	Chains.				
In No. 1 Split.....	72	901	900	− 1	− ⅛
„ No. 2 „	134	1074	1135	+61	+5·6
„ No. 3 „	129	1006	958	−48	− 4¾
By Leakage	....	490	478	−12	− 2½
Totals	....	3471	3471	•	•
In the second set of Experiments.					
In No. 1 Split.....	72	3102	3043	−59	− 2
„ No. 2 „	134	3024	3045	+21	+0·7
„ No. 3 „	129	2719	2770	+51	+1·8
	....	875	862	−13	− 1½
	....	9720	9720	•	•

In the first experiment, the difference between observation and calculation amounts to $\frac{1}{9}$ per cent. in one case, and reaches to between 5 and 6 per cent. in another case; but in the second experiment the least error is less than $\frac{3}{4}$ per cent., and the greatest is less than 2 per cent.; and on comparing the two cases it may be seen that in one split the error is converted from a plus to a minus one; and the split, where the least difference arises in the first experiment, is that where the greatest arises in the second, which indicates, clearly enough, that the slight discrepancies between the observed quantities, and those calculated on the principles advocated in this communication, may, and probably do, really arise from mere errors of observation, for the most part.

In concluding, it may be remarked, that it is highly desirable that as many of the members as may have time and opportunity to institute experiments, on the particular point in ventilation, which has here been investigated, should do so; and produce the result of their experiments at the meeting of the Institute, to be held in August.

No one can reasonably say, that either this, or any other principle in ventilation, is unimportant; inasmuch, as the results of a more correct knowledge of any of the laws of ventilation, than that which we at present possess, cannot be foreseen; and the mere chance of a better acquaintance with the laws, leading to an improvement in the general practice of ventilation, ought to be sufficient, when it is remembered how much depends upon it, to stimulate all parties interested in the matter, to endeavour to throw new light upon it.

In making any such experiments, the temperatures and inclinations existing in different parts of the air-ways ought to be observed; the former at the times of trying the experiments, so that their effects may be allowed for in the conclusions.

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, JULY 1, 1858, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

The PRESIDENT, on taking the chair, said that the meeting had been specially summoned to discuss the papers of Mr. Marley and Mr. Bewick on the Ironstone of Cleveland. The Council had taken into consideration the arrears of discussion of the papers read at the Institute meetings, in consequence of the regular meeting being only once in two months, and in consequence of the regular meetings having, from unavoidable occurrences, been postponed. The Council had arranged, likewise, that a paper should be read at the August meeting by Mr. Wales, on the Ventilation of Coal Mines, and that the discussion on the Lundhill Accident should also be resumed. Under these circumstances, they thought it advisable that an extra meeting should be held for the discussion of the papers on the Cleveland Ironstone.

The PRESIDENT then said, he thought the discussion would be best commenced by asking Messrs. Marley and Bewick if they had any additional information to give, or observations to make, explanatory of their respective papers.

Mr. MARLEY replied, that he had not much to add, as at the last October meeting he made such remarks as he thought were proper to give by way of explanation. One thing, however, he would advert to, and that was respecting the commercial discovery of the ironstone in the north part of Cleveland. A person of the name of James Burlinson had been going round the district with printed circulars, declaring that he was

the first person who discovered the existence of the ironstone, and endeavouring to raise subscriptions in consequence of such discovery. Now he (Mr. Marley) had, in his paper, alluded to Mr. Burlinson, and gave him credit for everything which, in his opinion, he merited; but he denied that he discovered the ironstone in question. If he (Mr. Marley) were to express any further opinion on the point, he would say that the commercial credit of the discovery, and subsequent application thereof, was due to Mr. Vaughan. Another thing he would also beg to allude to, by way of explanation, was a section given at page 201, Vol. V., of the Ingleby Manor mines at Burton Head, in which are to be seen the main geological features of Cleveland, in connection with this ironstone; namely, three main freestone beds, a coal seam above the so-called top seam of Cleveland, and the main alum shale; but, inasmuch as there is another thin coal seam often met with in that district in the oolite formation, it would be as well to indicate its position more plainly, and the matter stands thus:—

	Ft.	In.	
Soil, &c.			
Shale	5	0	
Black shaley coal	1	6	Ingleby top or third seam.
Freestone	5	0	flaggy freestone.
Shale	5	0	plate or shale with coal pipes.
	16½ ft.		

But the plate or shale with coal pipes he would now give in further detail. This third seam of Ingleby is not yet wrought at any other place; but a seam very similar to it has been discovered at Hawnby, about six miles north of Helmsley, with the following section, viz.:—

	Fath.	Ft.	In.
Soil and gravel	1	1	0
Freestone	0	2	0
Sandy shale	1	1	0
Freestone	0	3	0
Sandy blue shale	1	0	0
Clay band ironstone	0	0	1
Blue shale	1	0	0
Ironstone bed, 2ft. 6in. to 2ft. 9in., average	0	2	7½
Soft blue shale, with occasional ironstone nodules	0	0	7
Of about 2 to 4 inches thick, but say average only	0	0	0½
(Proved into) coarse shale	0	3	0

Mr. Marley next adverted to Mr. Bewick's paper, and to his remarks as to the so-called top seam of ironstone, which in that gentleman's

paper was called the "top seam of the lias formation." Now, inasmuch as they both agreed as to the identity of this seam, and that he was right mechanically, while Mr. Bewick was right geologically, the point was, which mode was the best of naming this seam? In his opinion both might, perhaps, be wrong; as, if a still higher seam were found, then his designation was at fault. Mr. Bewick's mode involved the naming of the formations, and thus became too long; therefore, in future, the nomenclature of the seams would be better done by adopting some characteristic of each seam, as in the case of the main seam of the south part of Cleveland, where it is divided, and called the "Pectin" and "Avicula" seams. The next and more important point in which Mr. Bewick and himself were at issue (and on which a variety of opinions were held amongst the members), was as to whether the Rosedale Abbey Magnetic Ironstone was a *vein* or a *bed*, and, if the latter, whether it were the sc-called top seam or not. Now, inasmuch as he had not had an opportunity of revisiting that place since his first visit in April, 1857, he would leave the discussion thereon to Mr. Bewick and the President, both of whom, he understood, had made recent visits to it; and also as to the fact of the top seam having since his visit been proved to be lying regular on each side of the magnetic quarry, it seemed questionable whether he might be right in calling it a disjointed patch of the top seam or not. Again, from the result of further drifting and boring, there was nothing *as yet* to prove it to be a regular *stratified bed;* but, on the contrary, in some instances corroborative of its being a vein, and having overspread itself to some extent, as in the case of the "*flats*" in lead veins. The President now admits that, if a bed, it is geologically situated below the top bed. He (Mr. Marley) now understood that Mr. Wood admitted that the drift two miles off (viz., Sheriff's drift) was not magnetic, *as stated in the October discussion.* The three bore-holes now in course of being made would go far to put this question at rest.

Mr. Marley, in answer to some remarks of the President as to the possible extension of the Durham coal-field into Cleveland, did not wish to hold out, by any means, the probability of such extension, but would still stand on his concluding remarks in last October minutes, wherein he denied that anything between Castle Eden and the Tees had yet been proved, which makes it geologically *impossible* for such to be continued.

Mr. Bewick then made the following statement and remarks on Mr. Marley's paper:—In the year 1840, I, along with my late father, made

a survey of the lias ironstone from Whitby to Skinningrove. Leaving it there, we next traced it from Slapewath, near Guisbro', along the side of the hills where it is now so extensively worked. My father was then, and had been for some time previous, working the same stone in the royalties of the Marquis of Normanby, at Kettleness and Staithes, for Messrs. Thompson, Brothers, of Wylam Ironworks. As I stated in my paper there are only two workable deposits of ironstone in the lias formation, and for that reason I named the higher one *the top bed.* The ironstone found above them belongs to another class of rocks in the oolitic series. The bed in question is known by that name, and will continue to be known by it; and, I think, to avoid confusion, it would be better to designate those above it *the oolitic beds,* especially as there are other ironstone beds above the one alluded to by Mr. Marley as the third bed, but which he does not yet appear to have met with. It is, however, of course a matter of indifference by what name they are designated, so long only as they are clearly distinguishable by such name. I beg to remind Mr. Marley that, by what he has now expressed with regard to the Rosedale ironstone, he has materially qualified what he stated in his paper. He says nothing in his paper about the top seam being altered in its condition by volcanic action or otherwise, but simply mentions his belief to be "that the magnetic ore is a disjointed patch of the top bed." I presume Mr. Marley, in what he has said with reference to Messrs. Bolckow & Vaughan, confines himself to the Eston district. Mr. Bewick then made the following observations on his paper on the Rosedale Ironstone:—I have paid two visits to Rosedale since I last had the honour of appearing before you, and as I saw nothing on either of those occasions to induce me to alter my opinion as to the nature and extent of this deposit, but much to strengthen it; and as extensive trials have been, and are still being, made there, perhaps it would enable you all the better to understand the subject about to be discussed, if I were to draw a rough sketch of the strata in which the ore is found, and in which the trials are in course of being made. Mr. Bewick then drew a sketch of the strata similar to that in his paper, Vol. V., and proceeded:—You will observe from this that the whole of the strata on the west side of Rosedale forms a crown, from which you will perceive there are, of course, two dips in opposite directions—one to the south and the other to the north, the direction of the valley being nearly north and south also. The top bed is rising and dipping in the same manner. On the north side of the crown, and a considerable distance up the valley, a

drift has been driven into the side of the hill to some extent, in the top bed, called "Sheriff's Drift." On the south side of the crown, and no great distance from it, is the quarry of magnetic ore, 70 feet thick, and not yet bottomed, and from 20 to 30 yards wide; and beyond this again, to the south, another drift has been commenced, also in the top bed. The main drift, however—a rough sketch of which you will find annexed to my paper—is commenced between the quarry and the latter drift, and, after being worked to the extent of about 90 yards, intersects the magnetic ore, and afterwards is driven, I believe, in a direction nearly parallel to, and in the heart of it; and on reaching the distance of about 200 yards, another cross drift is driven at right angles from it, in a south direction, thus cutting the dyke transversely. This drift, on reaching the distance of about 16 yards, cuts the shale where the ore is found resting against it, much in the same way as is represented in the section accompanying my paper; and I have no doubt whatever if another drift had been driven from the north side of the main one, that it would also have cut the shale in that direction, and the breadth of this deposit would at once have been ascertained. Two borings have been made, each of which have gone through the ore, but, as I believe, they have both been made on the same side of the centre of the dyke, this is only what might be expected. The thickness of the ore in one bore-hole is 30 feet, and in the other between 30 and 40 feet, but as those experiments have been under the supervision of the President of this Society, and Professor Phillips, perhaps the President will be good enough to furnish us with some account of them, as well as his opinion generally as to the nature and extent of this extraordinary deposit: after which, I shall have an opportunity of replying to his remarks, and I beg to assure the meeting, if he convinces me of my error, I shall be the first to acknowledge it.

The President stated, that at present he had not much further information to give on the subject of the Rosedale deposit, than he had done in October last. Operations in drifting and boring were going on under the direction of Professor Phillips and himself; but, as these were not yet completed, it would be premature to offer any decision as to the precise nature of this important deposit.

It had transpired from Mr. Marley's account of the Cleveland ironstone, and from other sources, that there were two extensive beds of ironstone—locally termed the top bed, and the main bed; and, it ap-

peared that, besides there being in other parts of the district detached or occasional other beds or nodular strata of ironstone, there existed in Rosedale a deposit of a different description from those great and other detached beds of ironstone. That, whereas, the produce of the main beds yielded from 28 to 35 per cent. of iron, the Rosedale deposit yielded 40 to 50 per cent., or sometimes more. That the Rosedale deposit is of the nature of a solid dark oolitic ironstone, merging into a compact iron ore—that it is magnetic with polarity, and is likewise peculiar from the entire absence of shells, the presence of which is the general characteristic of the other ironstones.

This deposit as previously explained, was at first discovered at a quarry, about a mile from Rosedale Abbey, on the brow of the hill forming the west side of the valley, where it has been worked to a depth of about 60 feet. It there assumes an ellipsoidal or large nodular structure, though apparently stratified. The stratification is, however, almost entirely obscured by the nodular structure of the ironstone. And there has been a great difference of opinion, as will have appeared from a previous discussion on this deposit, whether it was of the nature of a bed, or was a dyke, as explained by Mr. Bewick. A drift has been set into the hill, in a direction nearly west, or at right angles to the valley, in order to ascertain the extent and peculiar features of this deposit, and if it was a bed, or only a mass of magnetic stone in the fissures of a dyke, or only a casual deposit emanating therefrom.

This drift, a sketch of which, is shewn in Mr. Bewick's paper, has now been driven 265 yards; at the extremity of the drift, the ironstone had been found to be 32 feet in thickness, of good quality, and magnetic. A specimen from the drift-face 100 yards within the solid rock gave 45·5 per cent. of iron. The ellipsoidal, or nodular structure of the ironstone, at the face of the drift, has, however, almost entirely disappeared, and it has become distinctly stratified, and divided into several distinct partings, the stratification dipping slightly north-west. At the face of the drift, likewise, which is 6 feet 3 inches in height, there is 11 feet 9 inches of ironstone above the top of the drift, and 14 feet below, making a bed of 32 feet in thickness altogether, resting on grey shale; the bed above the ironstone being a thin bed of dark shale, above which, is sandstone. That the ironstone at this place occurs in the shape of a bed there can be no question. Near the face of the drift, a cross gallery is driven about 20 yards and at right angles to the line of

the drift. Where this gallery branches out from the main drift, there is 14 feet of ironstone below, but the inclination of the beds being considerable, the ironstone bed forms the bottom of the cross drift in about 16 yards, the shale rising up from underneath the ironstone.

Another conclusive proof of this ironstone existing as a bed is likewise proved from a boring made 413 yards in advance of the drift which has passed through the top bed of ironstone at a depth of about 40 fathoms from the surface, 16 feet 3 inches in thickness, and at the depth of about 50 fathoms, it also passes through the Rosedale bed 32 feet thick; and it is necessary to remark, that the position and depth from the surface of the Rosedale bed in the bore-hole corresponds precisely with the inclination of the beds at the face of the level.

The following is a section of the strata in the bore-hole :—

SECTION OF THE BOREHOLE MADE BY THE ROSEDALE IRON CO., 1858.

	Fath.	Ft.	In.
Ironstone ramble	0	3	0
Shale	0	4	0
Brown sandstone	5	2	0
Grey sandstone	1	3	0
Brown sandstone	5	2	0
Metal (shale)	0	5	0
Coal	0	0	4
Metal (shale)	0	2	6
White sandstone	0	3	0
Metal (shale)	2	1	6
Grey and brown sandstone	2	3	0
Metal (shale)	3	2	0
Brown sandstone	2	3	6
Metal (shale)	3	5	0
White post (sandstone)	0	4	0
Metal (shale)	0	5	5
White post (sandstone)	0	1	3
Metal (shale)	1	3	6
White sandstone	0	3	3
Shale, with ironstone nodules	2	5	0
Magnetic ironstone	2	1	3
White sandstone, hard	1	2	0
Shale, with ironstone nodules	1	1	6
Black shale, with ironstone nodules	0	4	0
Magnetic ironstone	5	2	0
Grey shale	1	1	0
Total Fathoms	51	4	0

These explorings show therefore, that the Rosedale band of ironstone exists as a bed, at the distance of 265 yards from the quarry, and again as a bed at the further distance of 403 yards, making altogether a bed of 668 yards of such stone, upwards of 32 feet in thickness. Two bore-holes have recently been set out, each 200 yards to the right and left of the bore-hole, 403 yards in advance of the drift, to ascertain the extent or breadth of the ironstone bed, but as it will be some time before these borings can reach the depth where the beds are supposed to exist, the result cannot be communicated to the Institute until they are completed.

Enough has been explored to prove, in my opinion, the existence of a distinct bed of ironstone of at least 30 feet in thickness, of an entirely different character from either the *top bed* or the *main band* of the Cleveland ironstone, its position being about 60 feet below the top bed. The main band occurs in the lower part of the valley of Rosedale, to the south, but its thickness is not correctly ascertained, neither is the depth at which it lies below the top bed determined. The quality here is not supposed to be good. But it may here be remarked, as illustrative of the general character of the ironstone beds of Cleveland, that both the bands seldom occur in perfection in the same locality.

In the discussion at the meeting in October, 1857, it was stated that the Rosedale band was supposed to have been discovered at a place about two miles up the valley, and that a drift had been set into the hill to prove if such was the fact, which was named "Sheriff's Drift." The section at this place is as follows, from the surface:—

	Ft.	In.
Thick beds of gritstone shale, immediate cover of an upper bed of ironstone or iron ore, ellipsoidal structures, much browned, and scrappy	8	0
Shale	4	0
Lower bed of ironstone, stratified in four beds, marked by ellipsoidal structures round pale blue cores	6	8
Soft ironstone in beds, more argillaceous, and containing shells	4	0
Soft ferruginous laminated bed	4	0
Shale	0	0

A specimen from the drift face, 70 yards within the solid rock, gave 36·4 per cent. of iron. The exploring at this place was not carried further than 70 yards into the solid ground, when it was abandoned, in order to prosecute the more important experiments in the vicinity of the quarry. A drift has been set into the hill, about half-a-mile west of the

quarry, at a lower level than the present drift, in order to drain the entire depth of the ironstone deposit, and thus to explore further the nature of the deposit.

The PRESIDENT then explained, by diagrams, the particulars as regarded the drifts, borings, &c., and proceeded: As stated on a former occasion, a slip dyke was discovered by the drift near the quarry, running in a direction N.N.W. and S.S.E., the downthrow being towards the W.S.W.; and it has been very generally supposed that the peculiar character of this deposit, and, indeed, its formation, were due to the effect of this dyke, and that, in fact, the deposit did not extend beyond the immediate vicinity of the fissures of such dyke. It was well known that ironstone was found in the fissures of dykes where little, if any, existed in the strata through which they passed, or in the beds in the immediate vicinity of such dykes; and the hematite iron ore formation in Cumberland was an instance of vast masses of ironstone assuming the character of beds, in strata not peculiarly or generally favorable to the production of ironstone. In the case of the Rosedale deposit, he did not suppose that the dyke had no effect on this peculiar mass of ironstone, on the contrary, in his opinion, the existence of this dyke had, in all probability, occasioned, or imparted, the polarity to the magnetic nature of the ironstone. There could be no doubt of the existence of the deposit as a bed, at least to the extent to which it was proved; how far the deposit existed as a bed on each side of the dyke he was not prepared to say, the borings which were in course of being made would prove this, to a certain extent, and, therefore, they must wait until those were completed for the proof of the further development of this extraordinary deposit. He had been informed that magnetic ironstone of a similar character existed in other parts of the district; and no doubt the attention which had been devoted to this, and the commercial value of such a deposit, would lead to further investigation and enquiry, and therefore, they might hereafter hope to obtain further information on this important subject. They must bear in mind, however, in the consideration of this subject, that the facts already ascertained prove that the bed or mass of ironstone, as well as the beds above and below, are equally displaced and depressed by the dyke, showing, therefore, that it is an operation subsequent to the deposit of the beds.

A long and desultory conversation and discussion then took place, after which the following observations were made by

Mr. BEWICK, who said, after hearing the President's explanation of his

theory with regard to the nature and extent of this deposit, he was bound to say that his opinion remained the same. From the bore-hole put down from the surface, (No. 1 bore-hole) it was proved the ore was running in a direction nearly west. From the cross drift to the south, it was proved also, that its breadth in that direction to where it cuts the shale, was only from 16 to 20 yards, and from the difference of its thickness in the two bore-holes; he thought it was clearly manifested, that it was spreading out much the same as represented in the section accompanying his paper, and which was further confirmed by the position of the ore at the face of the south drift, where it was found resting against the shale at a considerable angle with the surface.

He had only to state, with reference to the dislocation of the strata mentioned by the President, that he had traced the top-bed from 12 to 15 feet in thickness, from the crown before-mentioned along the side of the valley, till it met the dyke at the quarry; passing which, it continued its course southwards, without any visible disturbance, but what may have been occasioned by the dyke. He was at Rosedale on Monday last, (28th June) where he discovered that the only ore which was really magnetic, was confined almost entirely to the space laid open by the quarry, and that the stone north and south of it, though discoloured, was not affected by the magnet. He was, therefore, more convinced than ever, that the magnetic portion of the deposit was very limited indeed in its breadth.

In answer to some queries put by Mr. Barkus, relating to the thickness of the deposit of the quarry,

Mr. Bewick stated, the thickness of the ore at the face of the quarry was 70 feet, without going through it. How far it might go down, and what direction it might take, he said it was impossible to say. He believed, the strata overlaying it was a subsequent formation, it was therefore not likely to be found on the high moorland ground. He had heard that the magnetic ore had been discovered in Farndale, a valley about three or four miles to the west of Rosedale, but he had not seen it.

The meeting then adjourned.

The PRESIDENT then said,—At the Council meeting held on July 24th, he submitted to the Council if it was not desirable that the same rule which applied to the Council with regard to some of them retiring every year, should not be also applied to the President and Vice-Presidents; and, stated his willingness not to present himself for re-election, if the adoption of such a rule was the wish of the members of the Institute. He proposed, at such meeting, that a circular should be sent to each member, which they, no doubt, had all received, stating his intention to propose the following resolution, at the annual meeting, namely, "That the Resolution of the annual meeting of 1858, with regard to the Election of the Council, be made applicable to the superior officers of the

NORTH OF ENGLAND INSTITUTE

OF

MINING ENGINEERS.

GENERAL MEETING, THURSDAY, AUGUST 5, 1858, IN THE ROOMS OF THE INSTITUTE, WESTGATE STREET, NEWCASTLE-UPON-TYNE.

NICHOLAS WOOD, ESQ., PRESIDENT OF THE INSTITUTE, IN THE CHAIR.

The PRESIDENT—I am sorry to say that our Secretary is not present to-day, and that his absence is occasioned by illness. But I am very happy to inform you that he is recovering, and I hope we shall soon have his services again. In his absence, I will read over the proceedings of the Council.

The minutes of Council Meeting of July 17th, was then read.

The PRESIDENT then continued,—Mr. Wales has promised a paper on the Lundhill Colliery accident, and on the system of Ventilation of Coal Mines generally, illustrated by drawings and diagrams. I am glad to say that his diagrams are here, and that his paper will be read after the routine business is disposed of.

The PRESIDENT then said,—At the Council meeting held on July 24th, he submitted to the Council if it was not desirable that the same rule which applied to the Council with regard to some of them retiring every year, should not be also applied to the President and Vice-Presidents; and, stated his willingness not to present himself for re-election, if the adoption of such a rule was the wish of the members of the Institute. He proposed, at such meeting, that a circular should be sent to each member, which they, no doubt, had all received, stating his intention to propose the following resolution, at the annual meeting, namely, "That the Resolution of the annual meeting of 1858, with regard to the Election of the Council, be made applicable to the superior officers of the

Institute; and, that accordingly, the President, two Vice-Presidents, and three members of the Council be ineligible for re-election in each succeeding year." And he stated his intention, that if this resolution were passed, he should not present himself for re-election.

That the next meeting of the Council was held on the 31st, at which, he was not present. A resolution was passed at that meeting, to the following effect:—"Resolved, that a letter be written to the President, expressing deep regret, that he should have decided not to present himself, and, hoping that he will re-consider the matter, and allow himself again to be put in nomination for re-election. The zeal and energy with which he has forwarded the objects of the Institute since its commencement, has induced the Council to come to this decision."

PRESIDENT then proceeded,—The next point was that of obtaining tenders for the printing and engraving of the Society's publications for the ensuing year. At the commencement of the Institute, tenders were received from different parties for the printing and publication of the Transactions of the Institute, Mr. Reid was the successful candidate on that occasion, and it has been continued with him ever since. The Council now wished that tenders should be again taken, and he, therefore, put a resolution to that effect to the meeting; the resolution thus put was carried unanimously.

The PRESIDENT then observed,—Before reading the minutes of the Council of to-day, he would beg their attention for a few minutes to an explanation upon the foregoing proceedings, especially with reference to the circular it was thought desirable should be sent to the members generally. He had only one declaration to make with reference to the office of President, and that was, that anything he could do for the benefit of the Institute, he need hardly say, he would continue to do to the latest period he was able to do it. He trusted the attention he had already paid to the progress of the Institute was sufficient to justify him in making such an observation, and that in issuing that circular he did it solely with a view of promoting the permanent interests of the Institute. He would beg to refer them to what took place in 1856 on that subject, which he would read over to them, and which occurred at the Annual Meeting in August of that year:—viz., "The President next called attention to the election of officers for the ensuing year, and noticed a suggestion in the minutes of the Council as to the desirability of some of the Council retiring every year, such course being adopted by similar institutions, that the Council declare three out of the Council, and one of the four

Vice-Presidents, should retire and be ineligible, and this change was deemed advisable with the view of infusing fresh blood into the Council. The result of the proceedings at that meeting was, that with respect to the President and Vice-Presidents, it was deemed that the change would be premature that year, that the Council should make the matter more fully known, and that the retiring of the three members of Council was to depend on the number of times they attended the meetings." A great many gentlemen who are present to-day, were present on that occasion. It was fully discussed whether it was desirable that the President and Vice-Presidents should undergo the same ordeal as the Council. At that meeting it was considered not desirable that such should be the case, and, ultimately, the following resolution was passed, "That no change in the election of Vice-Presidents is desirable; that three of the Council should retire annually, and that the three whose attendance at the meetings of the Council have been fewest, be ineligible for the following year." On that occasion it was applied exclusively to the Council.

The President then stated, he thought it only right that in public institutions, such as that under consideration, it was very desirable that every person should be satisfied with the officers of the Institute, and that every one should have an opportunity of aspiring to all the higher situations of trust; and that every member should be eligible for election for the office of President or Vice-President at every Annual Meeting. No doubt the rules make every person eligible, but there seemed to be a sort of feeling that the President and Vice-Presidents, as a matter of courtesy, should not be subject to this rule. He thought it was desirable that this question should come before the meeting in a more tangible shape than hitherto, and, therefore, he thought it was advisable to propose the resolution, previously alluded to, with a view of bringing it to a practical test, whether it was the wish of the meeting that such a proceeding should be adopted or not. Since that circular was sent to the members, he had been communicated with by several members of the Institute, who had expressed a wish that he should allow himself to be proposed as President for another year. He begged to say, that his only object in issuing that circular was to do what he considered was best for the interests of the Institute; and that, after considering the matter carefully over, he left the matter entirely in their hands. If they thought it was desirable he should not present himself for President at this meeting he would do so; on the contrary, if they were of opinion he should, he would

equally abide the result. At their meeting to-day the Council passed the following resolution,—"That the Council recommend that this subject be taken into consideration at the next Annual Meeting." Of course this prevented him from proposing the resolution which he stated his intention of doing, and left it optional for them to deal with the office of President and Vice-President as they thought proper. With these observations he, therefore, left the matter entirely in their hands. He had, as he had previously stated, only one object in view, and that was, to benefit the Institute; and whether it was as President, or in any other capacity, they might rest assured that no effort on his part would ever be wanting to promote the interests of the Institution.

The Report of the Council was then read by Mr. TAYLOR.

Mr. WM. BARKUS, sen., in the absence of Mr. Boyd, read the Financial Statement.

Mr. REID remarked that nothing had been expended in the purchase of books during the past year.

The PRESIDENT—The next business, is the members to be proposed; and I shall be glad if any gentleman has any to propose. I beg to propose Mr. Edmund James Smith, of London, Agent of the Ecclesiastical Commissioners, who, they knew, held a very large extent of coal property, in the County of Durham. Mr. Thos. Bailes, jun., of Thistleflat Colliery, was also proposed.

The PRESIDENT then said—There is nothing more of a routine character, except the question of a Mining College or School, for the education of mining students. I am afraid that during the past year much progress had not been made in this very desirable object. Owing to my illness in the beginning of the year I could not meet the Warden of the University of Durham; and, since that time, gentlemen have been very much occupied in Parliamentary business and elsewhere, so that the committee has not had an opportunity of meeting the gentlemen of the University. The subject, however, has not been lost sight of, and I will read two or three letters I have received from the Warden of the University, and from Professor Chevallier, on the subject; letters which express their willingness to consider any proposition we have to make. You are aware that we set off at first with the intention of establishing an independent college in Newcastle, and the Duke of Northumberland came forward in the most princely manner, by offering a large sum of money, as an endowment; on one condition only, which has proved fatal to the scheme, namely, that we should provide

a certain other amount for the purpose of building and establishing the college. I regret that the coal trade did not follow up that proposition of his Grace in the manner which, in my opinion, they ought to have done, if they had considered their true interest; as, there can be no doubt, it is for the interest of the trade that such an institution should be formed. Whether it was that the trade not being in a good state was the cause or not, we did not, however, get the money, nor even the promise of it, and, therefore, we could not fulfil the conditions proposed by his Grace. Feeling we could not accomplish the erection of an independent college, we turned our attention, as you are aware, to associate ourselves with the University of Durham, and Mr. T. J. Taylor and I have been in correspondence with the Warden and Mr. Chevallier, as before stated, and the following are some letters received by me on the subject:—

College, Durham, Dec. 15, 1857.

DEAR SIR,—The Warden and Senate desire me to inform you that the University of of Durham is ready to give its best attention and exertions, as far as its means extend, for furthering the objects proposed by the Committee for Mining Education.

It appears to the Warden and Senate, that the regulations of the University now in force for Students in Mining and Civil Engineering, may, without inconvenience, be so modified, as to be adapted to the contemplated scheme.

A Committee, of which the Warden and I are members, has been appointed to confer with your Committee, whenever it be convenient to you.

I remain,

Dear Sir,

Yours, most faithfully,

TEMPLE CHEVALLIER,

REGISTRAR.

To Nicholas Wood, Esq.

Durham, Feb. 10, 1858.

MY DEAR SIR,—I am glad to learn from the Warden, that your health is so far re-established as to induce you to hope to be present at the meeting soon to take place at Newcastle, with the view, among other matters, of forming a connection between those interested in the Education of the *Mining and Engineering Classes*, and the *University* of Durham.

The University is quite ready cordially to co-operate in such a work, by any means not inconsistent with its own primary institutions. And I think, there would be no difficulty in making an arrangement, by which a College, subject to its own independent government, should give to the University and receive from it, advantageous support.

There would probably be in such a College, a number of students who would not require the kind of instruction which a University could more properly supply; and those

students might be entirely under the care and instruction of the officers of the College. Others, would be sufficiently advanced, to avail themselves of the lectures and general studies of the University; and those students might be matriculated as members of the University, and pursue the studies to such an extent as appeared desirable and practicable.

If it were a part of the scheme to erect a College, and the University possesses property available for that purpose, there would be every disposition to facilitate the arrangements necessary for such a scheme.

If you would wish for any more definite information respecting the University, which I might be able to supply, I shall be happy to answer any enquiries; or, if you deemed it more satisfactory, I would call upon you any day that you would appoint, if you will tell me the most convenient train by which I may reach you.

Believe me,

My dear Sir,

Yours, very truly,

TEMPLE CHEVALLIER.

To Nicholas Wood, Esq.

These letters prove that there is every disposition on the part of the University of Durham to associate with us in promoting our object. I trust you are still of opinion that such an association with the University would be desirable, and, if so, it would be advisable to instruct the Committee to proceed forthwith to communicate with the University on this subject.

Mr. TAYLOR—There is a Committee for the purpose appointed.

PRESIDENT—It may be desirable, notwithstanding, perhaps, to pass a resolution to instruct this Committee to proceed forthwith to communicate with the University. I shall be glad if any gentleman has any remark to make.

Mr. POTTER—Before you communicate finally with the Durham University, it may be desirable that the Committee should communicate with the coal trade as a body, and see if they are disposed to aid in the project in a pecuniary point of view.

PRESIDENT—I think that is very desirable; because, I am afraid, as far as pecuniary aid goes, the University will not be able to do much for us. Last year Mr. Robert Stephenson, Mr. Locke, and myself, with Mr. Ingham, had an interview with Lord Granville and Sir George Grey on the subject, and I am not without hopes that the Government will ultimately aid us in the project. When we met those gentlemen, Mr. Stephenson, Mr. Locke, and myself pointed out to them the great importance of the establishment of a Mining School, and stated that we thought the appointment of Inspectors was beginning at the wrong end;

that it would be much better to instruct the underground managers in the practical knowledge of mining, rather than keep them ignorant, and to appoint Inspectors over them; and that it would more effectually ensure the safety of the lives of workmen, if the youths who were intended as the future managers of the mines had a little more instruction in ventilation, and also in the practical management of mines. We pointed out that a payment of £2,000 or £3,000 a-year towards the support of a Mining College, would be a small sum compared with £14,000 a-year paid to the Inspectors of Coal Mines. We considered, if government thought it desirable that such a large sum as £14,000 a-year should be spent in inspection, it was surely desirable that the smaller sum of £2,000 a-year should be spent in education. Sir George Grey was so much impressed with the importance of the subject that he sent for Lord Granville, then President of the Council, under whose department the appropriation of money for educational purposes is placed, and he expressed himself strongly as to the desirability of Government aiding in the support of such an institution, if it were practicable to do so, and he pointed out to Lord Granville some mode by which he thought it could be done. The result of the conference appeared to be, that if we could show in what manner the scheme could be made practically useful, the Government would aid us. We explained, likewise, that we were in communication with the University of Durham, and that it was proposed to make it a branch of that institution, but with a separate management. Both Lord Granville and Sir George Grey expressed their opinion that if we could preserve that independence which such an institution required, connecting it with the University of Durham would be a great advantage; and stated if we could present to Government a tangible plan, they thought Government would assist us.

The following resolutions were then respectively put to the meeting and carried unanimously:—

Resolved,—

"That the meeting receive and adopt the Report and recommendation of the Council, and that the same be promulgated."

"That Tenders be received for printing the papers of the Institute."

"That a Catalogue of all Books, Plans, Sections, and Specimens, belonging to the Institute, be made out by the Council, and printed with the next year's Proceedings."

"That the Committee for the Mining College be requested to confer with the authorities of the Durham University, and also to communicate with the Government, and

to ascertain the feeling of the Coalowners on the subject, and the extent to which they are respectively disposed to encourage a project so well calculated, in every respect, to secure the mining interests of the kingdom."

The PRESIDENT—We have present with us to-day Dr. Ruhlmann of Hanover, Professor in the Polytechnic Institute there, who has come to this district to obtain information on coal mining. I beg to introduce him to the meeting.

Mr. WALES then presented his paper, and several diagrams to illustrate his views of the subject of the Ventilation in Coal Mines, the President remarking that perhaps the best course to pursue would be that Mr. Wales should read his paper through without interruption first, and then that the meeting should discuss seriatim the various sections illustrative of the subject.

ON THE LUNDHILL ACCIDENT

AND ON THE

VENTILATION OF COAL MINES GENERALLY.

BY MR. JOHN WALES.

IN accordance with previous intimation, one object of our assembling here to-day, is to take into consideration the ventilation of coal mines generally, referring more particularly to the mode of ventilation in use at Lundhill prior to the explosion.

I feel that I should only be taking up your time by remarking at length on the vital importance of a subject like this, not only to members of the mining profession but also to the community at large. Without considering the additional security of mining enterprise, you will agree with me, that the number of lives sacrificed by explosion, from time to time, renders it imperative that we should all bring our united efforts to bear on a matter of such importance as the present. When I look around me on the present occasion, and see so many very able men, some of whom have devoted their time and talents for nearly half a century to the subject before us, I may be allowed to express a hope, that

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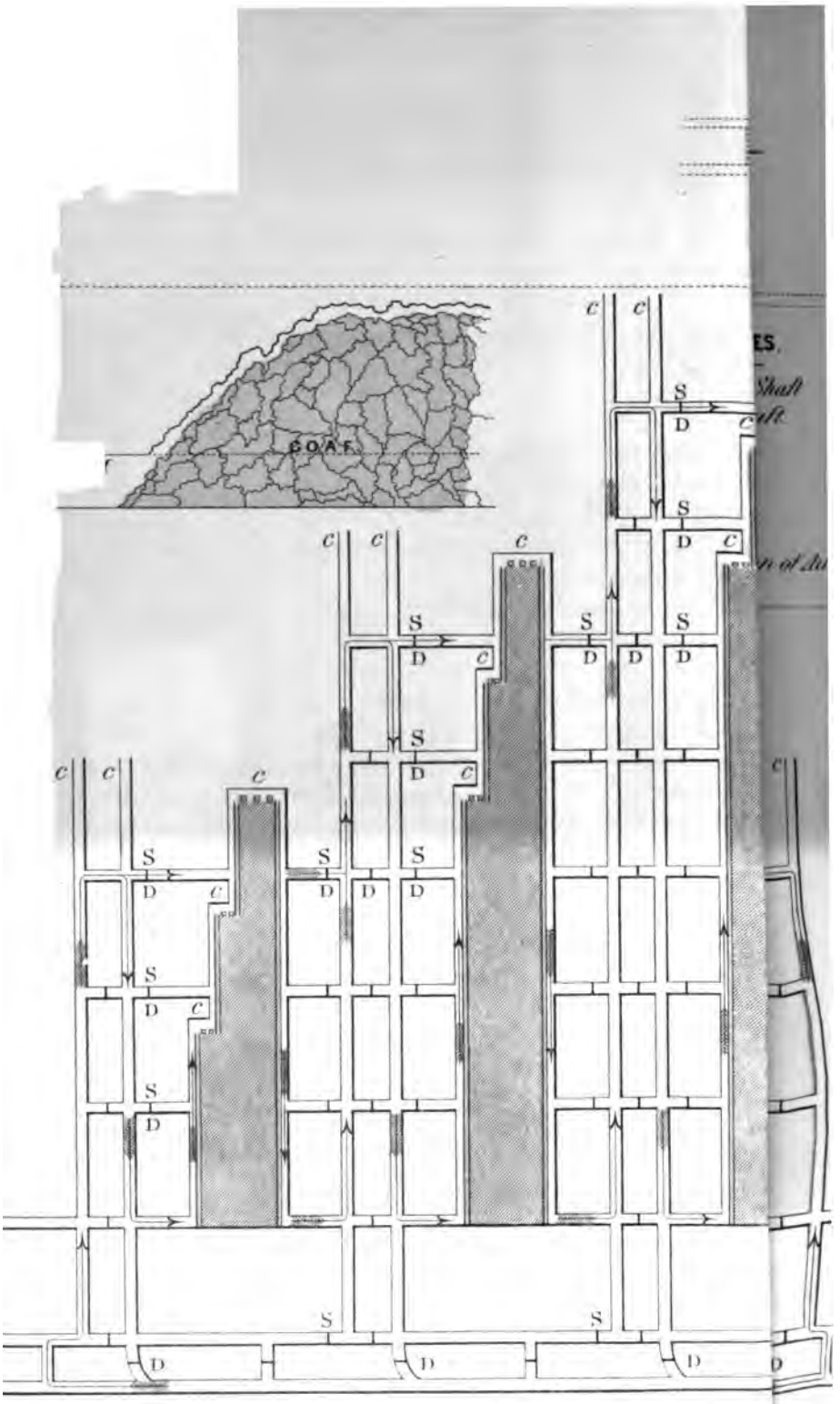
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before we separate to-day, a mass of valuable information will be brought to bear on the subject of ventilation, and that many important and practical suggestions may be offered in the course of our enquiry.

I apprehend, however, it will be unnecessary on my part to detain you with any lengthened introductory remarks, and, I shall, therefore, proceed at once to request your attention to the diagrams, which I have prepared on a large scale, for the better illustration of the different modes of ventilation.

Let us take first of all diagram No. I.

This represents a system of working coal similar to that frequently practised in the Yorkshire district. The Barnsley bed of coal is here supposed to lie near the surface, and, consequently, little or no gas is given off in the working face.

In this case naked lights may be used with impunity, and a great amount of care and attention is not required in regard to the ventilation of the mine, for the air may with propriety be conducted from board-gate to benk, and from benk to board-gate, as shown on the diagram, without incurring the risk of an explosion. When the bed of coal, however, reaches a greater depth, the gas cannot make its escape to the surface as in the former case. The ventilation of the mine, consequently, assumes a very different aspect, as will be explained on reference to diagram No. II; and I would here make the remark, that very great care should be exercised in approaching the line of demarcation which may be supposed to separate these two systems, in the one of which naked lights may be used, and, in the other, where to use naked lights would be dangerous and highly improper.

Let us now proceed to notice diagram No. II.

This represents the system of working and ventilation in use at Lundhill Colliery at the time when the melancholy accident occurred, by which so many lives were sacrificed. It will be seen that there are two distinct shafts here represented—the one for the downcast, and the other for the upcast; and, that, as soon as the air arrives at the bottom of the downcast, it is divided into two equal portions—one going in the north direction, and the other in the south. Let us follow that portion which goes to the north. It will be seen that this is conducted to the northernmost part by means of various doors placed in the separate board-gates. The air is then subsequently conducted around the mine by means of doors placed in the various openings, technically called slits. [Those doors are for the purpose of allowing the coals to be brought

from the face benks, and from the following-up benks.] The air then proceeds up and down the edge of the goaf, and around the various workings, as delineated by the arrows, until it reaches the top of the furnace-board, when it unites with that portion of the air which has ventilated the southern district, in a similar manner to that we have just described. These united currents of air now proceed direct to the furnace, or "dumb drift," as the case may be.

I shall now offer a few brief observations on the defects of this particular system. And, first, it will be generally admitted, that where, as in this system, so many doors are required for carrying the air around the various benks and board-gates, the chances of derangement and accident are proportionately increased. It is, therefore, a safe general rule, (if we wish permanently to secure the ventilation of our mines) "*that the number of doors should be diminished to as great an extent as possible.*"

Having referred to the excessive number of doors required, I shall next direct your attention to the danger which may be apprehended under this system, from the use of the naked lights. These, it appears, were used at the working face of the benks and board-gates.

Now, if any of the numberless doors I have referred to, were accidently left open or deranged, the air would naturally be diverted from its proper course. The consequence would be an insufficient dilution of the gas given off by the goaf or benk; and when this gas comes in contact with the naked lights, which are shown to have been generally used, we may well imagine a result to follow, which, it is fearful to contemplate.

Again, there is an additional insecurity, on which, I would remark, in connection with working the coal at the face of the "benk." And, here it may be asked, "what is a benk?" A "benk" is a place where the coal is in process of excavation; and, at Lundhill, the benks were worked to a width of forty yards, and to a length, varying from two to three hundred yards. But, to proceed with our remarks:—The strata above the cavity or goaf,—which is thus made,—of necessity, breaks down and falls to a considerable height. For the better illustration of this part of the subject to those who are not conversant with mining operations, I have prepared a longitudinal section of what we might conceive this goaf to be. It will be seen from a glance at this section, that there are great cavities left above the fallen strata, forming, as it were, a reservoir or dome, in which, gas, when given off in the dislocated strata, will lodge.

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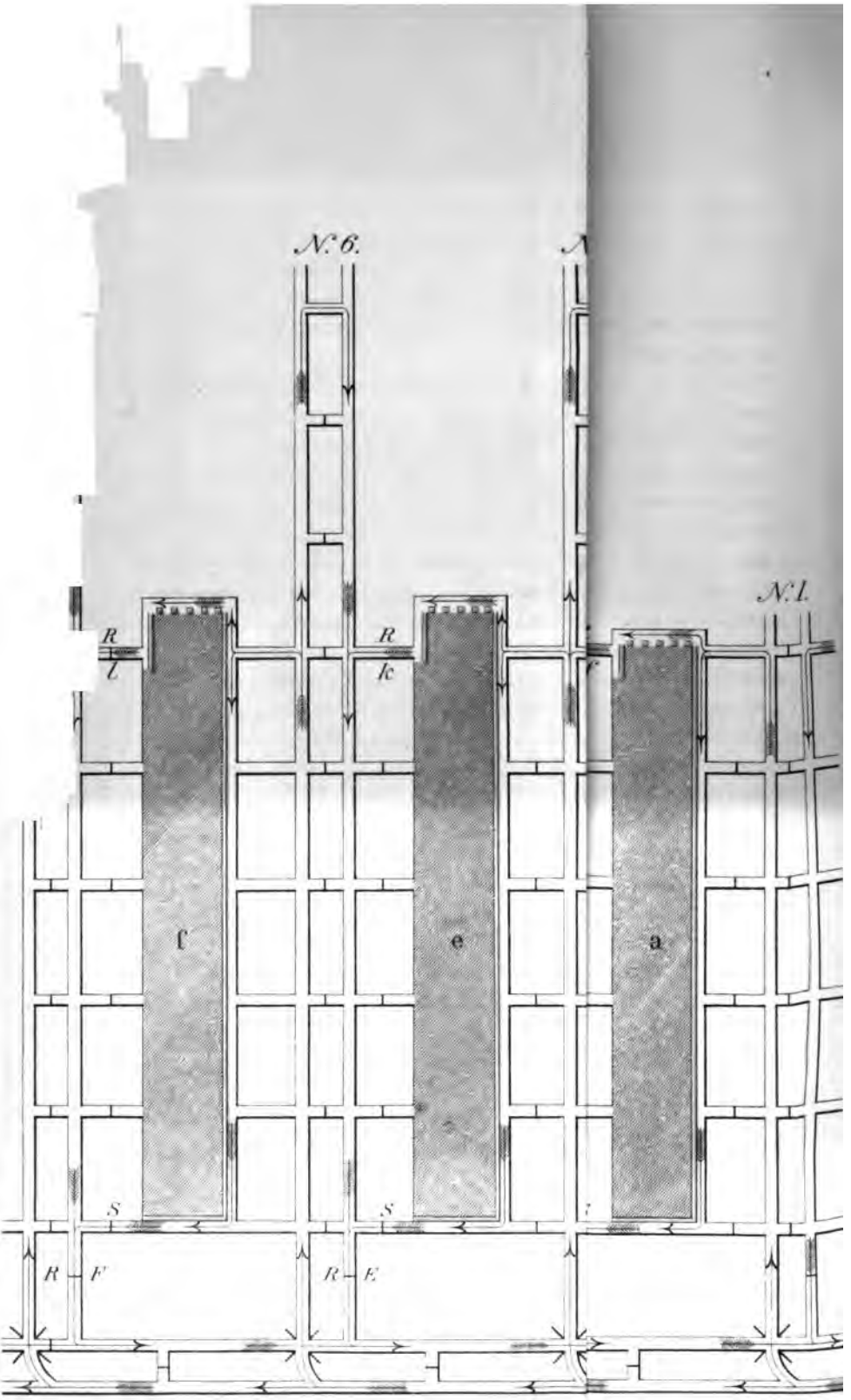
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Assuming, then, that there *is* gas lodging in this dome (as probably was the case at Lundhill); assuming, too, that a fall of stone at the top or side of this dome were to take place, the result, as a natural consequence would follow, that a portion of gas (in whatever state it might then be) would be forced out of the goaf, and so come into dangerous contact with the naked light.

There is yet another source of danger, arising from the use of these naked lights, on which, I would wish to make a remark. We are all aware from experience, that a diminution of the density of the atmosphere, indicated as it is, by a fall of the barometer, causes the gas to expand and come to the edge of the goaf. In this, as in the former case, we may well imagine the same unfortunate consequence from the gas coming in contact with the naked lights. It is scarcely necessary to say more on this part of the subject. I think sufficient has already been advanced to shew the importance and the necessity, at all times, of keeping the naked lights at such a distance from the benk or goaf as that, if either of the above contingencies should occur, the gas in such goaf or goaves cannot by any possibility reach the naked lights.

I trust, I have said enough to make apparent, the propriety of keeping the naked light from the edges of the goaves, especially where gas is known or supposed to exist. I need not urge, at the same time, that the ventilation should be so arranged, that the air from the benk shall not come in contact with the naked light in the board-gate; on the contrary, that the air should be first of all, introduced into the board-gate, thence, into the benk, and afterwards pass off into the returns, uniting there with other currents of air, before reaching the furnace.

We will now pass on to diagram No. III.

This diagram represents another plan of ventilation, and differs from the former, in many respects. Instead of having doors placed in the board-gates and slits, to keep the air in its proper course—as under the former system—not a single door is required, according to this plan of ventilation.

Allow me to give a few words of explanation as to the advantages and disadvantages of this mode of ventilation. In the first place, a much larger quantity of air will be required to give each benk or board-gate a separate and distinct division of fresh atmospheric air. Let us suppose, by way of illustration, a colliery similar to Lundhill, and suppose it to yield 500 tons of coals in twelve hours. For such a quantity of coal the requirements in regard to working and ventilation would be

twelve benks and twelve board-gates. Now, to give each benk and board-gate a separate division of air, according to this proportion, would require a very large aggregate indeed. If I remember correctly, the quantity of air at Lundhill colliery, previous to the explosion, was 60,000 cubic feet per minute. This, I should consider, more than an average for a colliery of such extent. If the workings could have been so arranged as to have twelve divisions of air instead of twenty-four, then each benk and board-gate might have had a separate portion, and, in this case, I could willingly have sanctioned such a mode of carrying on a mine, for I am of opinion that, with 8,000 cubic feet per minute, twelve divisions of air are much more likely to be attained than twenty-four.

To have twenty-four divisions in one pit, each supplied with such a quantity of air as this, appears to me the very height of absurdity. As an instance, let us take the board-gates which have only two working places each. For each of these board-gates a separate division of air is required, and this, certainly, appears to me a very reckless expenditure of the important element which is so essential to the safe conducting of a mine, viz., atmospheric air.

One word as to the mode of working. You will readily perceive, that by having so many divisions of air, we must, of necessity, require a great number of regulators to enable us to apportion to each district its proper *quantum* of air. You will observe, that according to this diagram, regulators require to be placed in the slits or openings which communicate with the benks, for the purpose of bringing the coals through to the horse roads. Consequently, by this arrangement, the coals can only be brought from one side of the benks. This, you will agree with me, is a great obstruction to the proper working of the coal, and, it is scarcely requisite to state, that it is of little purpose having our ventilation well arranged, if, with such arrangement, we cannot work the coal to advantage.

Before concluding with this diagram, it is proper to state, that under this system the fresh air is taken into the face of each board-gate, where the naked light may be used with perfect safety, and we may observe, generally, that this arrangement will hold good with regard to ventilation, provided a sufficient quantity of air can be procured to supply the various divisions shown on this diagram.

We will now go on to diagram No. IV.

This system differs slightly from that of No. III, both as it respects the

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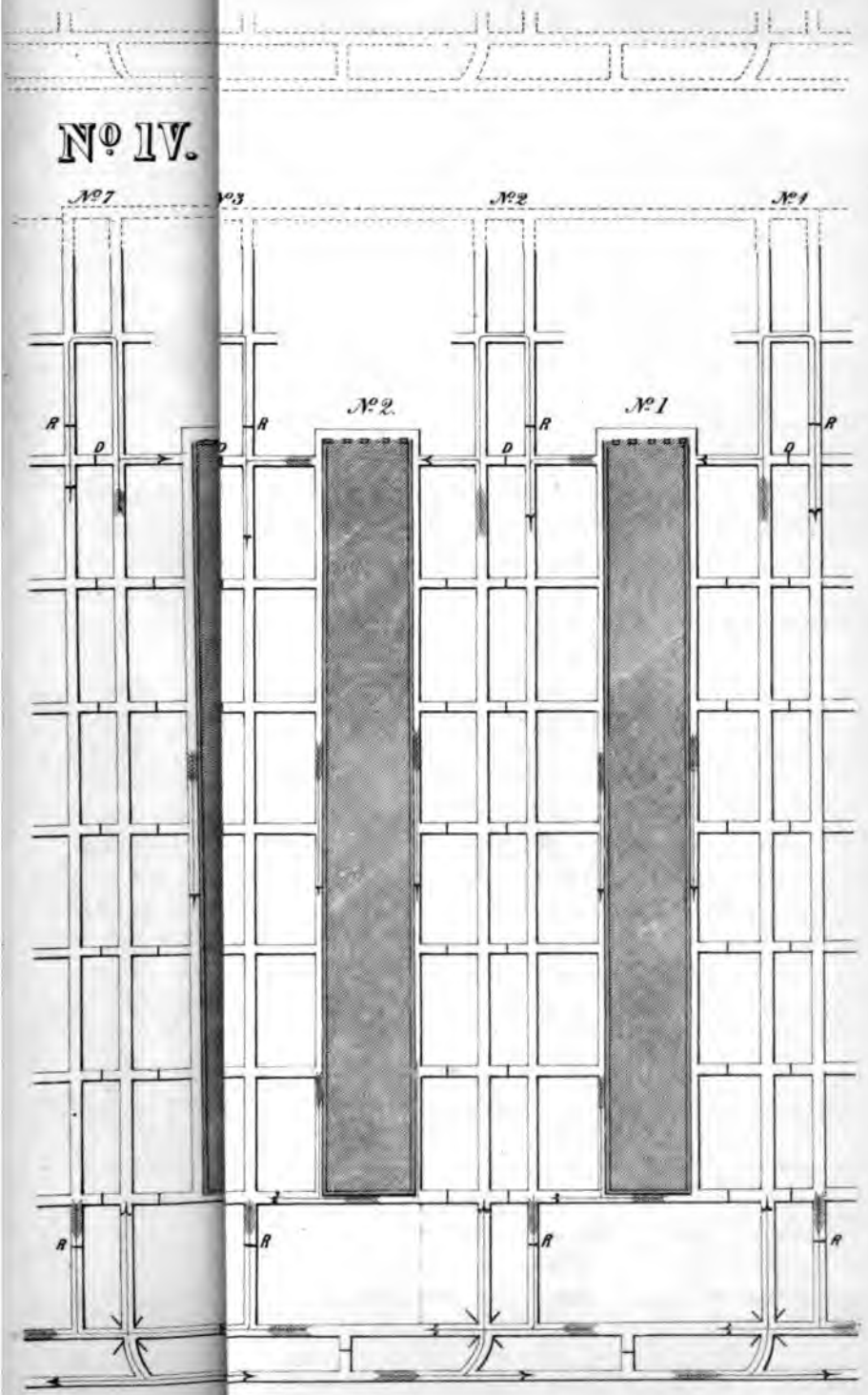

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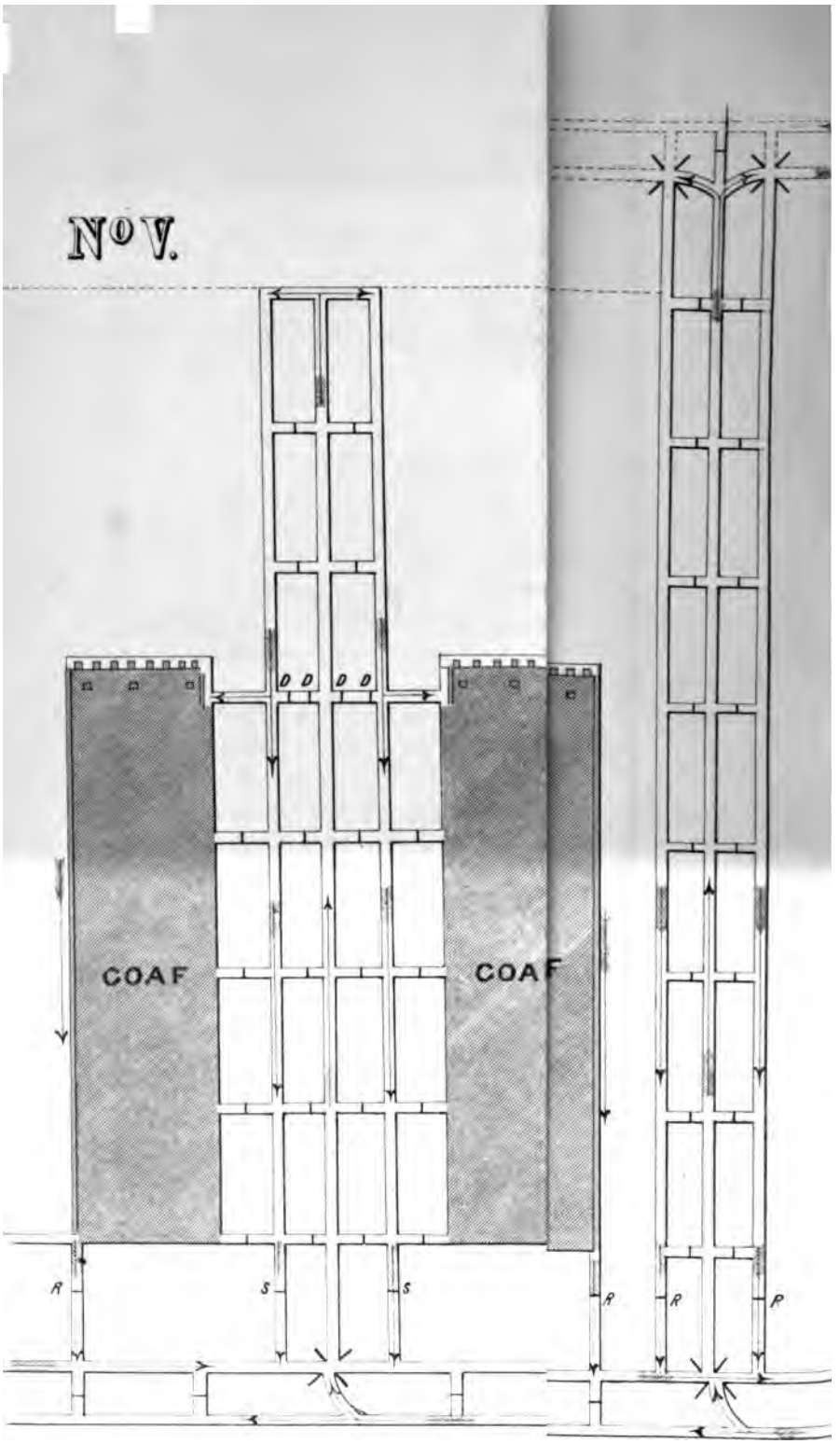
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ventilation of the mine, and the manner in which the coals are brought from the benks. In No. III diagram we made objections to the inconvenience of having only one way by which the coals could be brought from the various benks to the horse-roads. I shall now attempt to show, that by altering the mode of ventilation, the obstacle, I mean the regulator, can be removed from the slit next to the face of the benk, by this means enabling us to bring the coals from both sides of the benks to the horse-roads. To accomplish this, you will observe, that one door is required between each set of board-gates.

At first sight this diagram might seem to exhibit a very feasible system, but let us consider the arrangement as it regards the ventilation of the mine. In diagram No. III we found it impracticable to pass the air around the board-gates without having a regulator in the slit next to the face of the benk, but, by the arrangement shown in this diagram, it will be seen that we are enabled altogether to dispense with the regulators in the slits.

This change is effected by making the traverse of the air, required to ventilate the board-gates, shorter than the current of air required to ventilate the benk. By making this alteration we can now bring the coals from each side of the benk, which is, no doubt, a great advantage over the arrangement for working the coal as shown in diagram No. III.

Let us look once more at the system of ventilation represented in diagram No. IV.

Apparently, to the eye, the arrangements appear perfect in every respect.

But, if the door (*a*) between the board-gates be supposed to be open, what effect will then be produced on the ventilation of the mine?

This is a question of some importance; I shall leave this, however, as well as the explanation, &c., to be considered in the course of our subsequent discussion of diagram V.

By way of concluding my remarks on the Lundhill mode of working, I would observe, that after giving my careful attention to the plans already brought before your notice, I think it is evident, that even after all our care and trouble is expended on the application of regulators, with a view of enabling us to dispense with doors, so soon as the various board-gates and benks approach the barrier indicated by the dotted line, and the intermediate blocks of coal are removed, our regulators, for every practical purpose, are rendered entirely useless.

For the ventilation of our workings, we are, in such a case, compelled

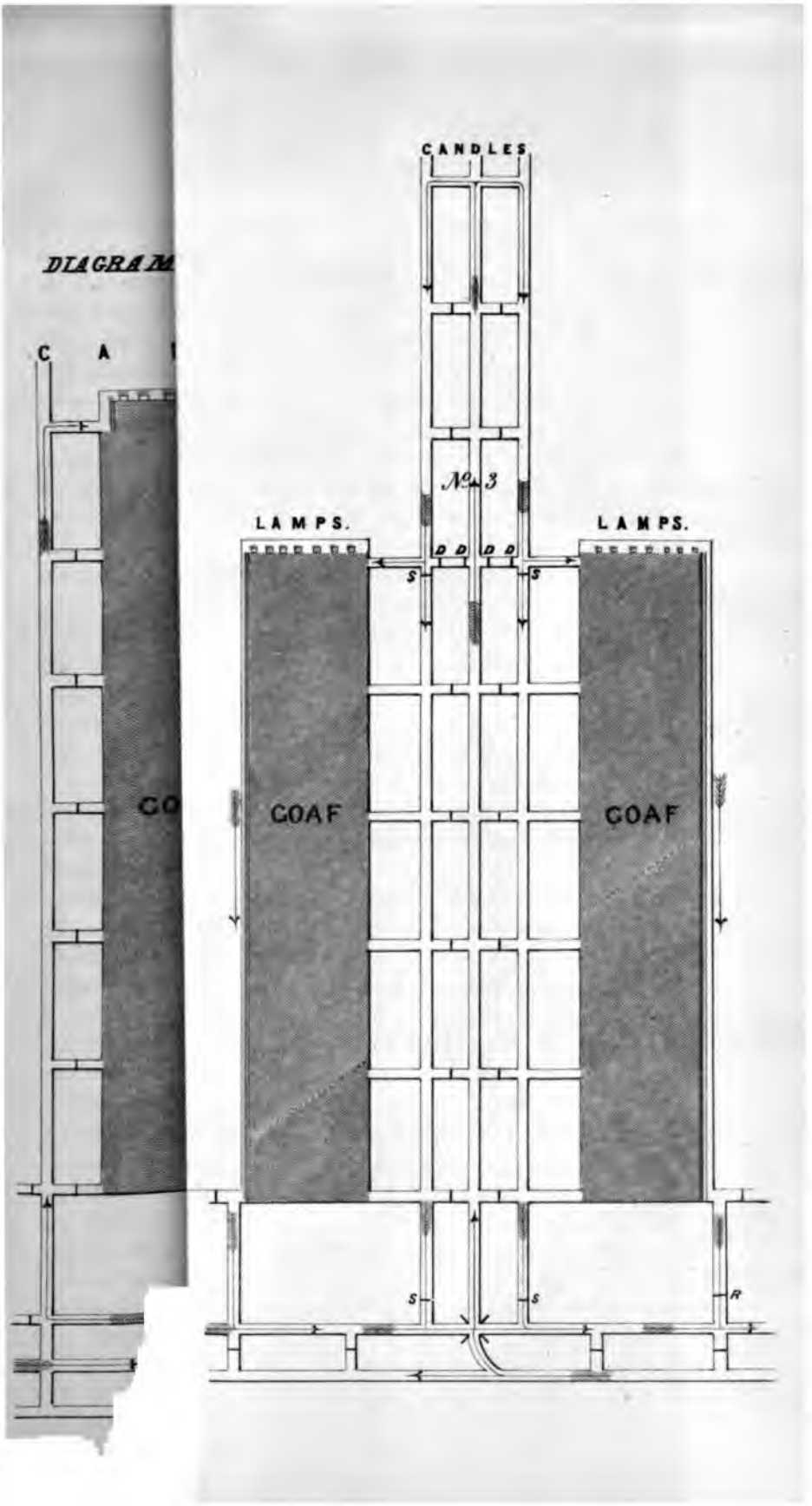
to have recourse to the old system of trap-doors, and this being so, we may safely conclude, that, under this Lundhill system of ventilation, the divisions of air can only be properly continued in use so long as the blocks of coal between the board-gates remain entire.

Having disposed of the Lundhill system, I shall now submit to your notice three different systems of working and ventilating coal mines, and it will be for you to consider whether or not any of them are to be preferred to the Lundhill plan, to which your attention has already been directed.

Allow me to refer you to diagram A. No. 1 on this diagram represents a portion of the workings of a pit of shallow depth, and, in such a case, as was observed before, naked lights may be entirely used. The ventilation under these circumstances is very simple, only requiring that every consideration should be used with a view of dispensing with trap-doors as much as possible. By referring to the No. 1 district of workings, it will be seen that two doors are placed in the rolley-way, to keep the air to the right and to the left. The distances, &c., being equal, it will be reasonable to suppose that the air will divide into equal quantities. The air is then conducted up each side of the workings and meets and unites again at the top of the middle rolley-way, down which it is conducted, and afterwards passes off into the return.

No. 2, on the diagram A, shows a different system again, and represents a district of workings where the coal lies at a much greater depth than in No. 1. We will assume, in this case, that inflammable gas exudes from the coal to such an extent that it is desirable that the safety-lamp should be exclusively used in the benks, while, by an arrangement for ventilating the board-gates with such currents of air as has been already described, the naked light may be used in them with the most perfect safety. Those who are experienced in the working of coal mines will be aware that to obtain the coal in the board-gates frequently necessitates the use of gunpowder, and, consequently, that the naked light here is in constant requisition, also, in the event of faults being met with by which the bed of coal may be "thrown" up or down, under such circumstances the use of gunpowder is also a great acquisition in making the horse-roads. Hence the advantages of our being able to introduce the candles here with impunity.

The air is carried up on either side of these workings in a manner similar to that in No. 1, but with this exception, that there are no doors required to bear the air to the right and left portions of the district, for it will be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seen that the air is divided into two equal portions, and is then carried up to the face of each board-gate, after which it returns to ventilate the benk, the two currents uniting again about midway across the benk, and passing thence to the return. The distance between the face of the board-gates, where naked lights are used, and the benks, where the safety-lamps are in use, will entirely depend on the discretion of the manager.

I might remark, before going further, that, in the ventilation of districts, we should adhere as much as possible to the rule "*never to go* beyond certain doors with the naked lights where there is the remotest possibility of the air from the goaf approaching the candle by the doors being neglected or left open,"—a contingency which you will at once perceive cannot arise according to the arrangements in No. 2.

If we suppose the doors were neglected at E, this would only take the air from the board-gates for the time being, and assuming gas to be given off in ordinary quantities the result would not be serious.

It might ignite at the miner's candle, but the explosion would be very limited indeed in extent.

I believe I have clearly explained, that when both doors in any case happened to be left open, the air would rush into the benk and not press from the goaf.

It will be observed, that there is a similarity between this plan of working and that at Lundhill, with this exception, that the barriers in the former system remain intact so long as the naked lights are used in the board-gate, so that the probability is, if an explosion unfortunately should occur, it will be principally confined to the district in which it originated.

No. 3 plan, on the diagram, is a system of working coal similar to that at Lundhill, with this sole difference, that the benks are much wider, —the divisions of air are fewer,—and the system approaches, therefore, much nearer to that of the "long-wall." The ventilation in this plan is so arranged, that the air is taken up in the middle of the workings and is divided at the top, one portion going to the right and the other portion to the left, being subsequently taken down by the edge of the goaf.

I freely confess that I have great doubts in my mind as to the practicability of upholding air-ways by the sides of goaves, but, so far as my information extends, it appears that this system is practised, and my desire that you should have an opportunity of expressing your opinion on this particular plan, induced me to bring it before your notice.

Before concluding altogether with diagram A, I would wish to point

out to you the manner in which a colliery may be worked under any one of the different systems here represented, keeping in view, at all times, the necessity of arranging the ventilation in such a manner that by splitting the air, trap-doors may be as much as possible dispensed with.

To take one of the above plans, say No. 3, instead of communicating the benks and board-gates with each other, work your intermediate district according to this plan, and afterwards proceed with the exploring drifts, or main levels, and leave coal (as per diagrams V. and VI.), of the same width as is required for No. 2; then form another district, and so on alternately, (see explanation of diagram No. VI.) By this arrangement of workings the ventilation may be regulated with the greatest precision. After the first alternate districts have been worked off, the coal which has been left for other districts can be commenced with, by going up between the goaves that have already been made. If it were asked how we can obtain command over the air when we communicate with the old works?—my reply would be, that if packing can be so put in as to carry the air up and down in these goaves, then this packing would undoubtedly hold good for the arrangement of the ventilation for the districts which have been left.

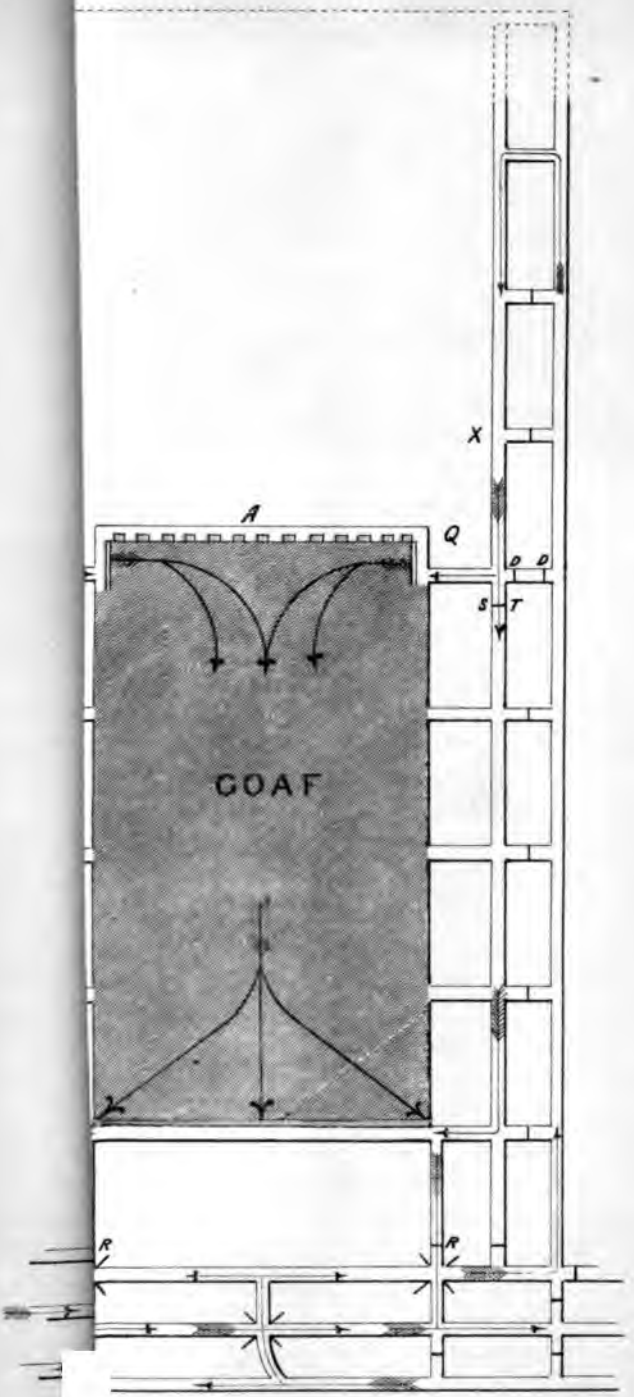
So much for the various systems of ventilation shown on the diagram.

Diagram No. VI. The system of working, here shown, is that of leaving every alternate district of coal to be worked off, after the district on either side (AA) has reached the barrier or boundary.

By this arrangement, the board-gates and horse-roads which were used for the original districts, can be applied, with equal advantage, for the getting of the coal from either side of the benks.

It will be seen, as indicated by the dotted lines, that places will have to be driven for the purposes of ventilation, which is easily arranged, as the currents of air from either side can be conducted by a door placed at *c* in the board-gate along the slit, where they will unite at (P), and go up to the face of the benk, after which they return and pass through their respective regulators.

If it ever occurred, however, under this system of ventilation, that the air in passing down the goaf should become too much contracted, thereby diminishing the quantity, a difficulty then arises, which may be obviated by removing the stopping at T, and placing a regulator at X, on either side, as the case may be. The air will then pass direct across the face of the workings from P to Q,—down the return board at T,—and through the regulators as before.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Now, according to this plan, we are enabled to work off the whole of the pillars or blocks of coal left between the board-gates, and this can be accomplished with the same permanent arrangements of ventilation as were previously in operation.

It is hardly necessary that, at present, I should detain you any longer with my remarks on this important topic.

You will see, that in my observations to-day, I have confined myself almost entirely to the Lundhill system of ventilation. Perhaps, at some future time, should opportunity offer, I shall, with your permission, take occasion to treat, in a similar manner, of the north-country system of ventilation, comparing it more especially with the plans at present in use in the midland districts.

There is one remark I should wish to make before concluding, and it is this, that while I have mentioned, in my observations above, the conditions under which candles alone may be used for the purpose of lighting, as also, the conditions under which it is desirable that candles and lamps should be combined for this purpose, at the same time I am fully aware, that there are mines which are liable to sudden outbursts of gas, and, under such circumstances, it would be unsafe to introduce the naked light. This is a matter, however, which must be left solely to the discretion of the manager.

Mr. Wales, after the reading of the paper, proceeded to explain diagram No. I, illustrative of the ventilation of a coal mine on the Yorkshire system of working where no inflammable gas existed. He stated that the arrows would show the direction of the air; the double cross lines at D representing doors; S, scales of air in the stoppings and doors; the single cross lines representing stoppings; A, the downcast pit; and U, the upcast pit.

The air, they would perceive, after passing down the downcast pit A, traversed the two water-level boards to the north and south, then around the face of the benks east and west to the furnace board F, down which it passed to the upcast pit U, and Mr. Wales pointed out that the sole dependence of the circulation of the air was on the doors D being kept constantly shut.

The President—How are the following-up benks ventilated?

Mr. Wales—The bearing-up doors, it will be perceived, have scales of air in them which air will pass up the following-up benks, provided

that no air escape across the goaf, or along the headway at the bottom of the benk. These scales of air at the doors it will be seen are common to all the following-up benks.

The PRESIDENT—The only air passing to the benks is from the scale at the doors?

Mr. WALES—Yes, going from benk to board-gate, and from board-gate to benk.

Mr. POTTER—But the split of air of those side benks may get across the goaf?

Mr. WALES—No; the air has a free course up the side and across the face of the benks, and the double yellow lines alongside the following-up benks show the packing, which is supposed to be tight, so that the air, having a free course up the side benks and around the face, goes that way in preference to pressing through the goaf.

Mr. POTTER—When you split the air, one portion going to the face of the benks and the other to the following-up benks, what prevents it crossing the goaf?

Mr. WALES—Nothing, except the packing, if we can make it sufficiently tight. In the Lundhill case it was supposed to be tight.

The PRESIDENT to Mr. Potter—What you want to know is, why the air does not cross the goaf?

Mr. WALES—Suppose a portion did, the greatest portion would go by the face of the following-up benks, and these two currents would meet at the slit nearest the face, and so pass through it to the next board-gate and benk.

The PRESIDENT—No doubt a portion of the air does press through the goaf. Gentlemen will recollect this was one of the reasons alleged for the cause of the explosion at Lundhill, viz.:—by a portion of air passing from one side of the benk to the other, and carrying with it the gas which it is supposed was lodged in the goaf. In one of the following-up benks there was a fall of stone, which prevented the free passage of the air up that side of the benk; two men were working on the opposite side of the benk with lamps with the gauze removed, or with naked lights; and it was supposed that a fall of stone had forced the air across the goaf, carrying with it some inflammable gas, and that the gas had been ignited at the lamps of these workmen, as they were found much burnt, and lying near the opposite slit.

Mr. ELLIOT—If we consider the white portion of the diagram the goaf of the benk, a pillar of coal, it looks very like the old-fashioned

system of coursing the air up and down every place. It appears, also, a very expensive system of taking the air up the benks by those packings, represented by the double yellow lines. It must be very expensive, especially where there is no gas. Why adopt a system so expensive?

The PRESIDENT—The packing is for the purpose of securing a road alongside the goaf to bring the coals out, as well as for air-way, and it is well known that there are several collieries working seams of coal, especially those containing a band of stone, by wide boards or benks, and building a pillar on each side of the board or benk, which serves the double purpose of forming a road-way and air course. These packings in the diagram represent the pillars in the cases alluded to where the air goes up one side of the pillar, or packing, and down the other.

Mr. ELLIOT—The air would always go through the innermost slit. The packing further down is discontinued as a tram-way.

Mr. WALES—It is as desirable to have a little air going round the goaf as not, when the roads are already made. I wish Mr. Elliot to understand that these roads were originally made to bring the coals from the benks, and the expense which he complains of, is not incurred solely on account of ventilating purposes, but chiefly to bring the coals along. This is the actual system practised at Lundhill, and, I suppose, they find it as cheap as any other, or they would not practice it to such an extent.

The PRESIDENT—Generally, the system of following-up benks is not practised. The more usual course is to take away the whole width at once. They are only adopted to obtain a larger diurnal quantity of coal in the same extent of space. In Lundhill the following-up benks were worked on both sides of the goaf, three on each side; and, consequently, a greater number of men were employed in working coal than could possibly be accommodated in the face of the benks. It is, however, the more general practice in Yorkshire to take the whole width of the benk at once.

Mr. WALES then exhibited diagram No. II., and the description having been read,

The PRESIDENT—Explain how the air is forced up the sides of the goaf?

Mr. WALES—With the packing.

The PRESIDENT—But, you know, the packing is not tight. This is not quite the same as in diagram No. I., where, you said, the following-up benks were aired by the scale of the doors. In this diagram I do

not observe any scale in the doors. And, I observe, the air is, first of all, taken up the one board-gate, across the slit between them, then brought down the other board-gate, and up the following-up benks on one side of the goaf, across the face, and down the following-up benks on the opposite side, and then up the next board-gate as before.

Mr. WALES—If the packing is tight, the air would so travel. It was represented that at Lundhill the packing was tight, and, if so, it would carry the air up to the face. If not tight, the air would cross the goaf to the nearest exit.

The PRESIDENT—In the Lundhill plans, as given to us at the time of the explosion, and shown in Vol. V., the darts show the air as passing down both sides of the benks, not up one side and down the other.

Mr. WALES—Then it would cross the next board-gate?

The PRESIDENT—Take one case, the air goes up the northernmost board-gate, then across the uppermost slit; part crosses the face, and part comes down the following-up benks on the north side of the goaf to the bottom. That portion which crosses at the face then comes down the south side of the goaf and joins the other portion at the bottom, and so passes up the next board-gate as before, except, as you will see a scale S at the uppermost door, where a portion is not forced down the south following-up benks.

Mr. WALES—What forces the air around the face of the benks, which is the longer distance?

The PRESIDENT—I suppose the passage across the bottom of the benk is not sufficiently large to admit all the current, and that, therefore, a portion is forced round the face and down the south side of the benk.

Mr. ELLIOT—I believe a portion of the air came down on each side of the goaf to the bottom.

Mr. WALES—When the air is taken up and down, as shown in the diagram No. II., it would look as if the place was ventilated. But, if only taken down one side of the goaf, then there may be a magazine of gas in the goaf, in which case the candles must be removed from the part which cannot be ventilated.

The PRESIDENT—If the air is taken up one side of the goaf and down the other, there will be pressure of air across the goaf, more than if the whole of the air is taken up to the top at once, and one portion of it brought down on one side of the goaf, and the other portion on the other, suppose one-half on each side. The former mode would be more liable

to bring the gas out of the goaf unless the goaf can be completely ventilated, which is, I believe, in general, impracticable to do, and, certainly, not to be depended upon to such an extent as that candles can be used with safety in its vicinity.

Mr. WALES—The air would, if coursed up and down on each side of the goaf, take the nearest course, which would be across the goaf.

Mr. TAYLOR—Is there a great deal of air-way at the bottom of the benk, along the headway? What height is kept where the goaf joins the headway?

Mr. WALES—There is not, in my diagram No. II., presumed to be any air-way at all. There is packing which operates as a barrier.

Mr. TAYLOR—What quantity of air was supposed to be in circulation at Lundhill at the time of the accident?

The PRESIDENT—We understood 60,000 cubic feet per minute, or 30,000 cubic feet in each of the north and south divisions.

Mr. WALES then explained the diagram No. II., and that portion of his paper relating to the falling of the strata in the goaf, and the consequences likely to arise from the use of candles in the following-up benks.

The PRESIDENT—I would beg to remark as to the open space at the top of the goaf—that immediately above the coal at Lundhill Colliery there is a considerable thickness of shale, which falls when the coal is removed. Above the shale is a thick bed of hard sandstone, which is, of course, difficult to break down. In the operation of working the benks, the shale would, in the first instance, fall down, the sandstone would then form the roof, and there would be more or less space between the top of the fallen shale, and the sandstone, which would be filled with gas, and which would form a magazine. Eventually, when a greater space was excavated, we may suppose the sandstone to break down, in the operation of which the gas would be suddenly forced out, and, if candles were exposed on both sides of the goaf, when such falls took place, we may easily imagine the result. The wonder is, not that explosions in such cases take place, but that they do not take place more frequently, no doubt, owing to the compact sandstone not being broken through at the time candles are exposed, or when the inflammable air is forced out.

Looking at the Lundhill plan, Vol. V., you will see that the last two slits next the face are open, and that notwithstanding the air is professed to be taken down both sides of the goaf, or following-up benks, to the bottom—we certainly travelled across the bottom of some of the benks,

which showed there was a passage along the head-way—the air could not, therefore, be forced up and down as shown in Mr. Wales' diagram.

Mr. WALES then drew the attention of the meeting to the number of doors implicated in the mode by which the Lundhill colliery was worked and ventilated, and the impropriety of using naked lights where gas existed so near the goafs.

Mr. ELLIOT to Mr. Wales—I think you said in your paper, at least so I understood it, that some portion of the workings might be worked with naked lights, in advanced places, provided they were a sufficient distance in advance of the goaf. Having regard to the fact that there are seven or eight goaves all to be ventilated, or, at any rate, worked, I would like to ask, how far these places ought to be in advance of the goaves, to enable the joint system of working with naked lights and lamps to be carried on with safety?

Mr. WALES—In ordinary cases, three pillars, each 60 yards long = 180 yards. You will see it in the next diagram. We will now pass on to diagram No. III., in which not a single door is used.

The PRESIDENT—In the former diagrams the whole air of the pit was divided into two splits, of 30,000 cubic feet each, supposing the whole to be 60,000 cubic feet. In this case it is divided into as many splits as there are benks and board-gates, for, I see, you air one benk and one board-gate by each split of air.

Mr. WALES—This diagram represents about half the extent of the pit's workings—each of the southernmost board-gates—a split is then taken to the left hand benk which airs the benk, and then meets a split from the next board-gate, and so passes to the upcast. The remainder of the air from the first split passes round the face of the board-gate, and meeting the split which airs the right hand benk, passes through the regulators to the upcast. It will, therefore, be seen that each main split of air ventilates one set of board-gates and one benk, and passes through the regulators A B C D E F along the main return underneath the crossings × to the upcast shaft.

The PRESIDENT—Let us first of all go into the question of the extent to which the air can be split. I suppose you would not require the same quantity of air for the board-gates as for the benks, and by the regulators you can give to each whatever quantity you please? Suppose there are eight benks, and eight pairs of board-gates, = 16, could you ventilate these with 70,000 cubic feet of air per minute, or even less? I think in the Durham district there are a great many divisions of the pits venti-

lated with less than 4,500 cubic feet of air. I wish to elicit information, as I believe there are few Yorkshire collieries with more than 70,000 cubic feet of air per minute. Suppose you had eight board-gates and eight benks, would 70,000 cubic feet of air be sufficient in a colliery yielding as much gas as Lundhill?

Mr. WALES—Scarcely, as it would require eight of each to produce 500 tons of coals in 12 hours. At Lundhill, at the time of the explosion, they were working night and day, and, therefore, they produced, with the same amount of workings, a larger quantity of coals in the 24 hours. I think 8,000 cubic feet of air for each benk, and 5,000 cubic feet for each board-gate per minute would be quite sufficient; and if there were eight of each, it would require 104,000 cubic feet per minute, which would be ample.

I shall now go into the mode of dividing the air, and will take as a standard the above quantities, commencing with Nos. 1 and 2 board-gates, diagram No. III., and suppose it is required that 8,000 cubic feet should go into each benk, and 5,000 cubic feet into each board-gate. I begin by allowing 13,000 cubic feet to pass through each of the regulators R A and R B, and, consequently, 13,000 cubic feet to pass up the main road of each board-gate. If there were no obstacles in crossing each of the benks *a* and *b*, the whole of the 13,000 cubic feet would cross these benks, and pass through the regulators R A and R B, the dotted board-gate No. 2 not being supposed to be driven.

Suppose then the dotted board-gate to be driven, without any stoppings in the slits, at *x y z*, no air would pass around the face of this board-gate. But suppose stoppings put into those slits, then what would be the result? The pressure or density on each side of *x* would be equal, and, consequently, no air would pass round the face of the board-gate. But suppose I put a regulator at R *f*, and allow only 8,000 to pass across the benk *a*, then the regulator R A having a capacity for 13,000 cubic feet, 5,000 cubic feet will pass around the face of the board-gate No. 2, and, meeting 8,000 crossing the benk, will unite at *o*, and so the 13,000 will pass through the regulator R A, and so on with the other benks and board-gates. 13,000 cubic feet, for instance, passing up the main board-gate No. 2 is divided at T, 5,000 cubic feet passing around the board-gate, and 8,000 cubic feet passing across the benk *b*, through the regulator R *g*, and meeting 5,000 cubic feet at P passing round the board-gate No. 3, and so uniting and forming the 13,000 cubic feet allowed to pass through the regulator R B, and so on with all the other benks and board-gates.

But it must be observed that the regulators R A, R B, R C, are not sufficient of themselves to distribute the air properly and regularly through the board-gates and benks, or to give to each their definite quantities. When the stoppings *x y z* are put into the board-gates, the distance which the air would then have to travel around the board-gate No. 2 would be greater than the distance which the current passing across the benk *a* has to travel, consequently, the latter current would fill the regulator R A to the detriment of the air passing around the benk No. 2. Consequently, it is necessary that there should be a regulator at R *f* to prevent more than 8,000 feet passing across the benk *a*, leaving room in regulator R A for the 5,000 feet to make up the 13,000 feet allotted to pass through the regulator R A.

These are given to show, that it is only practicable, where the distances or resistance of two currents is precisely equal, to pass equal quantities of air, of two currents, through one regulator, as proposed by some of the schemes before the public; and, that in the various irregularities of distances necessarily occurring in the working of our extensive coal mines, we can only depend upon securing to each district the requisite quantity of air by a separate regulator to each split or current of air; and, consequently, in addition to the regulators A B C D E F, it is requisite that regulators should also be put in the slits at *f g h i k l*, as shown on the diagram.

A long and desultory discussion then took place as to the question of, whether, supposing the separate currents of No. 1 passing across the face of the benk *a*, and No. 3 passing across the face of the benk *b*, to be of equal density, any air would pass around the face of the board-gate No. 2; and, also, as to the effect of the regulators A B C D, &c., and the regulators *f g h i k l*, which, though very interesting, as illustrative of the practical distribution of air, cannot, without the diagrams be intelligibly communicated in the report of the meeting. The conclusion being, that in a case of working, similar to that shown in diagram No. III., it was necessary that the additional regulators *f g h i k l*, should be adopted, to ensure the requisite current of air to the board-gates and benks respectively.

President—There is, then, no practical difficulty in doing away with all the doors, and working, as shown in diagram No. III., by regulators?

Mr. Wales—None, except that the coals cannot be brought along the slits in which the regulators *f g h i k l* are placed. If the regulators are placed in the doors, when the doors are opened the equilibrium of the ventilation would be destroyed.

PRESIDENT—Consequently, the coals of the benks must, therefore, in such cases, be brought out on one side only of the benks.

Mr. WALES to Mr. Elliot—You were speaking of the distance which the board-gates would be required to be in advance of the goaves or benks to enable candles to be used in the board-gates, though lamps are required to be used in the benks. I should say, with a current of 8,000 cubic feet per minute, and in a colliery not yielding more gas than Lundhill, candles might be used in the board-gates, though it was necessary to use lamps in the benks. Diagrams IV. and V. will explain this more fully.

Diagrams IV. and V. were then exhibited, and the observations on them read.

The PRESIDENT to Mr. Wales—Will you now explain how you can, with safety, use candles in the board-gates, it being admitted there is gas in the benks?

Mr. WALES—I would first explain, as regards diagram No. IV. It will be observed that the regulators are taken away from the slits and placed in the back board-gate, where there is no passage required for coal work. This is done effectually by making the length of air-course, from the board-gates to the upcast shorter, and the resistance less than from the benks, consequently, the preponderating pressure of the air is towards and around the board-gates. I, therefore, put a regulator in the back-board, which gives the requisite quantity of air only, to the board-gate, and doors being put in the slits of the board-gates allow the coals to be brought out on both sides of the benks. It will be observed, likewise, as regards the use of candles in the board-gates, that the first of the air passes around the board-gates, then through the regulator. This prevents any portion of the air from the benks reaching the candles of the board-gates.

Diagram No. V. is a still safer mode, being the same as is shown in No. 3, diagram A. In this mode the whole of the first of the air passes up the middle board-gate to the face; it is then split right and left, and passes into the benks, and so to the return drift. Double doors are put into the road-ways leading to the benks on each side, so that when one is open the other is shut. These doors are different from doors directing the main currents of a pit, if they are left open they only take the air off the leading board-gates, the current through the benks is not at all diminished, neither does it affect the general quantity of air in the pit, or in each split.

As regards the use of candles, the air from the board-gates pass to the benks, and there is no possibility of the air passing in the contrary direction from the benks towards the candles.

Mr. Elliot—That is, you ventilate the whole, and then bring it out to the broken or benks.—That is what you call perfect safety?

Mr. Wales—It cannot, perhaps, be considered perfect safety, but it is as perfect as I think possible. In the Lundhill ventilation, the air from the benks passed into the board-gates, hence the danger of having candles in the board-gates. In this case the air passes from the board-gates into the benks, and there is no possibility of the air "*backing out*" of the benks upon the candles in the face of the board-gates. If the doors are neglected the same result presents itself, and so long as candles can with safety be used in the board-gates, supposing no benks in existence, they can in this case be used with equal safety if there are benks; as, on looking at diagram V. it will be seen that the pressure of the air in any case must be towards the benks, and not from the benks to the board-gates.

Mr. Dunn—It is quite clear if the doors were left open, the air would pass into the goaf at all times, and not from the goaves into the board-gates.

Mr. Elliot—Are we dealing with a fiery mine? That implies danger. This is a case where gas is made in the mine.

Mr. Wales—The paper explains that this is a case where "gas exudes from the coal to such an extent that it is advisable the safety-lamp should be exclusively used in the benks, while, by an arrangement for ventilating the board-gates with such currents of air as has already been described, the naked lights may be used in them with the most perfect safety."

The President—I understand the case to be this—It is a case where you think you may, if the air is properly regulated, work the board-gates by candles, while safety-lamps are required in the benks; but, then, to do that with safety, you must have the air so arranged that in no case, by the neglect of doors or otherwise, is it possible that the air from the benks should reach the candles, but that the pressure of the air should be always from the board-gates to the benks. If you reverse it, and make it the tendency of the air to pass from the benks towards the board-gates, then it would be dangerous. The system you propose is to keep the board-gates sufficiently in advance of the benks, that, if the doors are neglected, the air passes into and joins the return air from the benks, both currents of air passing towards the upcast as usual.

Mr. WALES—Apparently the system shown in diagram No. IV. is complete, but if we open the door *a*, the effect will be that a portion of the air from the benk No. IV. would go into the board-gate No. V. Thus when the door *a* is opened, the shortest route for the air passing up the main road of board-gate No. IV. will be through the regulator No. 1, consequently, this regulator will be fully supplied with air. The other portion of the air crossing the face of the benk No. 4 will pass from *a* to *c*, and so proceed up the board-gate No. 5 to where we suppose candles used. This air will so pass, inasmuch as, though the route by the face of the board-gate is not shorter than the regular route by B C when the door is shut, it meets with less resistance by that route when the door is opened, for the quantity of air then passing from A to B is much greater than the quantity from *a* to *c*, and it, consequently, meets with more resistance, from its velocity and bulk, than the smaller quantity and less velocity of the air passing from *a* to *c*.

Considerable discussion then took place, between Mr. DUNN, Mr. GREENWELL, and Mr. WALES, on the effect of having a door in the situation of *a*, and the danger which would accrue if candles were used in the board-gate under such circumstances; it appearing, that in such a mode of distribution of the air, though apparently, at first sight, a safe mode, it would not be safe to use candles in the board-gates in such cases, if inflammable air prevailed to any extent in the benks and goaves.

The PRESIDENT—The mode of distributing the air is not safe, as, though, while everything is right, the air does not pass from the benks to the board-gates, and so candles could be used with safety. But, should the door *a*, for instance, be left open, accidently or negligently, then the tendency of the air would be to pass from the benks to the board-gates, a different state of circumstances coming into operation, viz., the velocity of the current in the main air-courses, and the pressure of the air, through the regulators not previously in operation, tending to divert the current in a different direction when the door is open than when shut. To Mr. Wales—Can you show us a mode of distribution of the air which is equally safe whether the doors are shut or open; for, as doors are liable to be left open at times, it is quite clear it would not be desirable that the safety of the mine should depend upon the contingency of any of the doors in the pit being neglected.

Mr. WALES—The mode shown in Nos. 2 and 3, diagram No. V., accomplishes the object, as, whether the doors are shut or open, the tendency is always for the air to pass from the benks to the return air-drifts, and not towards the board-gates.

The PRESIDENT—That is a system which you deem as perfect as you can suggest?

Mr. WALES—The application of the air is good, but the distance which the naked light ought to be from the benk must be decided upon by the viewer, as he must be guided according to the circumstances of the mine. There is another circumstance connected with this mode of working which I would wish to point out. It is all right so long as there is a barrier or rib of coal between one goaf and another; but if the mode of working implies that at some time or other the different goaves are permitted to have free communication with each other, as in the case of working away the pillars of coal forming the support to the board-gates, or the barriers between the goaves, then a different state of things exist, and it would be impracticable so to distribute the air, that candles could be used with safety where inflammable air exists in the goaves.

The PRESIDENT—When, for instance, the three goaves shewn in diagram No. V. are thrown into one, the effect of the regulator appertaining to each benk or goaf is destroyed, you cannot, therefore, pursue the system unless there is a solid wall between each benk? In both these benks, Nos. 1 and 2, diagram No. V., the air passes up the middle board-gate, which could not be the case if the walls or pillars on each side of the board-gates were taken away.

Mr. WALES—Just so.

Mr. BOYD—That is the proposition I made on a former occasion.

Mr. WALES, reverting again to the propriety of working the board-gates with candles, and the benks with lamps. If the doors at *a* are neglected, in diagram No. V., the gas in the goaf cannot get back to the candle. The air may become stagnant in the board-gate for a certain time, until the ventilation is restored, but it cannot "*back*" from the benk to the candle.

Mr. ELLIOT—This is a mixed system of candles and lamps, and you call it perfect safety?

Mr. WALES—Yes. I consider it a very good arrangement indeed, with respect to the ventilation, but, as I have already stated the distance that must separate the naked light and the safety lamp, must greatly depend upon circumstances.

The PRESIDENT—It is supposed to be a system of working where the coal requires blasting, and where candles are required to be used in the board-gates. But, suppose a fall in the goaf, would not that force out the inflammable air, and if so, what would be the effect?

Mr. WALES—The air would escape into the return air-course, and would not pass into the board-gates; and, by keeping the board-gates in advance of the benks, to such a distance as I have already described (180 yards), I do not think that there would be the slightest possibility of the gas in the goaf (with such a current of air as before-mentioned) ever reaching the naked light in the board-gates. I may say that it is always contrary to my practice and directions to the officials acting under me, ever to allow the edges of a goaf to be so charged with gas, that in the event of a fall of stone, the inflammable air might be forced on the candle. If a goaf were in such a state that this direction could not be carried out, I should then preclude the possibility of any accident occuring by altogether dispensing with candles in the district. We generally find that the greatest danger to be apprehended from gas coming out of the goaves is not from falls of stone, but from a diminution of the pressure of the atmosphere; yet, even in this case, with a good current of air, and with such a distance from the lamp to the candle as I have named, there is not much fear of accident. Falls in goaves do not generally force the air out to any great extent. It is necessary to observe, that when the roof is composed of very strong material, and it remains unfallen for a large area in extent, under such circumstances the naked light must be kept at a greater distance from the benk than in the former case, where the roof is composed of softer material.

Mr. ELLIOT—You have two systems. You have men working with candles in the whole, two or three pillars before the goaves, which contain gas, and in the working of the benks lamps are used. I do not subscribe to this being a perfectly safe plan. Assume, as we do, the goaves to contain gas—you assume by the neglect of a door, the air in the board-gate may become stagnant, and the face rendered foul. I do not think that this is anything like perfect safety, or either good working, when you admit the workings near the goaf may be filled with gas.

Mr. WALES—Assuming that gas may be lodged in some part of the goaf, not at the edge, for this would be improper, as previously explained, and dangerous. But assume that both doors are left open, *which is scarcely likely to happen*, and that the air is taken off the board-gate, and the naked light being within three feet of the face, the gas ignites at the same. Then I would say that the expansion of gas would have to be very extraordinary indeed to reach the goaf at a distance of three

pillars, or 180 yards. By this arrangement of doors it is obvious, also, that the inflammable air cannot be reversed in the direction of the candles, and if the doors were opened, the air would pass across the face of the benk to the return. The danger, incurred generally by the application of doors, is by such doors being neglected or left open, and that the air may be reversed in the direction of the candles. The doors in this case, which Mr. Elliot wishes to lay such stress upon, are, like all other doors, necessary for the ventilation of the mine, and, like all similar doors, when neglected, the current of air will be diverted from its proper course, and the ventilation suspended for the time being; but this will apply in all cases where doors are used.

Mr. Elliot—You assume, that the doors being left open, the result is that the ventilation is suspended.

Mr. Wales—As I stated before, when doors are neglected, the ventilation, as a natural consequence, must be suspended *more or less under all circumstances.* Let us suppose, that by the neglect of such doors, the gas accumulated to such an extent in the board-gate that, when ignited, the flame would extend 180 yards to the benk; in such a case it must be obvious to any one that it would be immaterial whether gas existed in the benk or not, as the consequences of so large a quantity of gas exploding would be fearful to contemplate.

Mr. Dunn—It is assumed the goaves are worked with lamps.

Mr. Elliot—But assuming the case put, that the doors are left open. Is it safe and right to have candles near where places are going that are full of gas?

Mr. Wales—I do not say near: I say at a distance of about three pillars, which is about 180 yards. I believe you spoke of a combined system of working candles and lamps, at the Lundhill inquest. I may observe that, in a pit like that of Lundhill, with such currents of air as before stated, viz., 8,000 cubic feet per minute passing round the board-gates and thence to the benks, I am of opinion that, under ordinary circumstances, gas would not be found at the edge of the benk; but, under extraordinary circumstances, it would be prudent to increase the distance from the face of the board-gate to the benk, or remove the naked lights altogether from the board-gates. It will be evident, if we can safely use the candles in the board-gates, that the expense of making horse-roads, &c., would be much less, as the use of gunpowder in making such roads is a great facility.

Mr. Elliot—I suppose at that inquest the general impression given

by the evidence was a tendency to condemn absolutely the use of naked lights under any circumstances. I said I did not go so far as that; neither do I go so far in this case. I say there are many cases in which a joint system might be used, but I think in the case Mr. Wales states it is pregnant with danger. I think great mischief is likely to result from working with candles very near the goaf.

Mr. WALES—Yes, too near; but, I stated that the board-gates were 180 yards in advance of the benks, and there would be, also, from twenty to thirty yards more from the benk, through the slit, to the board-gate, which makes the entire distance from the lamps to the candles about 200 yards.

The PRESIDENT—This is an important question, as there are several collieries which cannot, almost, be worked to profit unless candles are used. And it really appears the difference of opinion between Mr. Elliot and Mr. Wales is one of degree, depending in a great measure upon the quantity of gas evolved, as even, according to Mr. Elliot, there are cases where a joint system might be used with safety; and I do not think Mr. Wales wishes the system to be adopted except in such cases. We know there are a great many cases in the trade.where, for years, a mixed system has been pursued with safety, and where candles are used in the whole, and lamps in working the pillars or in the benks The question before us is not, whether in all cases it is perfectly safe to work with candles in the whole mine, in the vicinity of goaves containing gas. But, supposing the quantity of gas evolved in working the whole mine to be such that it can, in the ordinary sense of the term, be worked with perfect safety by candles, then would the proximity of a goaf containing gas render it unsafe to do so. We know that in working the whole mine we are liable to meet with sudden discharges of gas, notwithstanding which candles are used. Can, therefore, candles be so used within a certain distance of a goaf containing gas in an inflammable state? The distance therefrom is, no doubt, an element in the case; but we must assume that distance to be a safe one. Then the fundamental security assumed by Mr. Wales is, that the air should be so distributed through the mine, that in all cases, whether the doors are opened or shut, the tendency of the current of the air should at all times be from the whole mine towards the goaf, and not in the contrary direction; and this tendency, it is clear, must be such that, under no circumstance, should it be possible for the air, in consequence of falls in the goaf or of other causes, to back from the goaf to the board-gates or candles. If we admit that a sudden fall in the goaf might, by possibility, force the inflammable air out of the goaf upon the candles, then the system would not be safe; or, if we admit that the dis-

charge of gas in the whole mine may be such as that the workings may become foul, or be rendered inflammable, and that, if set on fire, such explosion might, by possibility, reach the inflammable air in the goaf, then in such a case the system would, unquestionably, not be safe. Is, therefore, the system of working, and of the distribution of air proposed in diagram No. V, such as would render it prudent to adopt a mixed mode of using lights, or, is the insulation of the two operations of working so complete, as that candles may with safety be used in working the whole mine, gas being admitted to exist in the goaves?

Mr. WALES—It is very important, not only in such a system of working as proposed in diagram No. V, but also in the ordinary mode of working pillars. And I would here observe, that too much care cannot be exercised in drawing a proper and safe line between "*safety*" and "*danger*;" and the manager ought at all times, of course, to exercise especial care to have the naked lights at such a distance from the goaves that even by a fall, neglect of doors, or any other contingency, there should not be the slightest chance of the air coming from the goaf to the candles. But as it is my intention to give illustrations of the various modes of working and ventilating coal mines, in connection with this question, practised in the counties of Northumberland and Durham, perhaps the further discussion of the subject might be postponed until these are before the Institute. I might be permitted to observe, that my bringing those diagrams before your notice to-day, is entirely with a view of suggesting some better and safer mode of ventilation than that practised in Yorkshire prior to the explosion at Lundhill colliery, in the Barnsley district.

The PRESIDENT—As we have a good deal of other business before us, probably the best arrangement would be to postpone any further discussion on this important subject until the next meeting, when we shall have the system as applicable to both modes of working coal mines before us.

The PRESIDENT then stated, that Mr. Atkinson had just placed in his hands two papers, containing experiments in illustration of his former paper on the splitting of air in coal mines, and as they contained a good many figures and detailed experiments, he presumed it would not be necessary to read them to the meeting, but to have them printed with the proceedings.

Mr. ATKINSON—There is one set of experiments made at the Grange colliery. The result is, that in the splitting of air the relative quantities in each split remains nearly the same; when the aggregate quantity of air is diminished, the variation, which was not more than $2\frac{1}{3}$ per cent., he attributed to the difficulty of measuring the precise quantities of air in each split, and not to any error in the theory.

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ASTOR, LENOX AND TILDEN FOUNDATIONS

The following is the account which Mr. ATKINSON submitted to the meeting, of Experiments on the proportions in which different gross quantities of air, circulating in a mine, in the unit of time, divide themselves over splits of various lengths, and offering different amounts of resistances, to the passage of a given quantity of air, in a given time.

The experiments were made by Mr. Cooper, on the 16th July, 1858, at the Grange Colliery, near Durham.

At this colliery there are two distinct pits, each 10½ feet in diameter, and 262 feet in depth, to the Hutton coal seam.

In No. I. experiment the air-ways were all in their usual state, except that there was a regulator, or contractor, in the main intake air-way, at a distance of about 10 yards from the downcast shaft, through which the whole of the air passing into the north, the east, and the south ways, forming the splits to be experimented upon, had to pass, before being split or divided. The three splits just mentioned, form the whole of the air of the Hutton seam of the colliery, excepting, only, that which goes to the underground engine, and that which goes to the stables.

There is, however, a further quantity of air passing in the shafts, which is employed to ventilate the workings in the Low Main coal seam.

The accompanying plan shows the relative positions of the air-ways in the Hutton seam workings, composing the different splits that were experimented upon. The furnace was driven, as nearly as practicable, at a uniform rate, for a few hours before, and also during the time that the experiments were being made.

During the period occupied in making the experiments, the following observations were taken:—

No. of the Experiments.	Time of taking Temperatures.	Regulator.		Barometer.			Thermometer.					Water Gauge.	
		Dimensions of the Opening in the Regulator at R on Plan.	Area.	At the Surface.	At the Bottom of the Downcast Pit.	At the Bottom of the Upcast Pit.	At the Surface.	Mean in the Downcast Pit.	Bottom of the Downcast Pit.	Mean in the Upcast Pit.	Return Airways in the Mine.	At the Separation Doors on Plan.	At the Main Regulator R on Plan.
	Hours.	Ft. Ft.	Sp. Ft.	In.	In.	In.	°	°	°	°	°		
1	11 p.m.	10 × 7	70	29·80	30·12	30·2	63½	63	62½	132	63½	0·3	
2	12 p.m.	6·66 × 7	46·62	..	..	..	..	..	62	132	63½	0·3+	
3	..	3·33 × 7	23·31	29·80	30·11	30·00	..	..	..	..	..	0·55	
4	..	3·33 × 3·5	11·66	..	..	..	..	..	..	..	..	0·55	
5	..	Closed.	0·00	..	..	..	..	..	..	..	..	0·80	0·70

The first series of temperatures were observed at 11 o'clock, p.m., immediately after measuring the air for No. I. experiment, and while the regulator, at R on the plan, had an opening of 70 feet area.

The second series of temperatures were observed at 12 o'clock, p.m., between the times when No. I. and No. II. experiments were made, while the opening in the regulator, at R on the plan, was 6·66 feet × 7 feet, offering an area of 46·62 superficial feet for the air to pass through.

The opening in the regulator, placed in the main intake, was altered in area (while the furnace was uniformly fired), in order to alter the gross quantity of air circulating in the unit of time.

The following are the particulars of the measurements of the air; the velocities were all found by timing powder smoke, over a known distance, several times in each case, and adopting the average as the real times, as exhibited below :—

No. of Experiment.		Longest or East-way Split.	Medium or North-way Split.	Shortest or South-way Split.
		Mean Length of Split, 3,260 Yards.	Mean Length of Split, 2,142 Yards.	Mean Length of Split, 1,490 Yards.
	Length of channel, in feet	120	120	120
	Area of section (mean) sup. feet..	29·75	38·50	33·25
		Seconds.	Seconds.	Seconds.
1	Mean time of air passing	14·00	34·90	36·17
2	Ditto	16·16	37·65	40·40
3	Ditto	18·00	36·86	42·90
4	Ditto	21·10	48·80	63·62
		Feet.	Feet.	Feet.
1	Velocity of air, per minute.....	514·3	206·3	199·6
2	Ditto	445·5	191·2	178·2
3	Ditto	400·0	195·3	167·8
4	Ditto	341·2	147·5	113·1

In order to prevent irregularities in timing the powder smoke, the powder was exploded a few yards to the windward of the commencement of the 120 feet distance, over which it was timed; and a signal was

given to the person counting the time, first, when the smoke reached the commencement of the 120 feet, and another when it reached its termination.

The following are the quantities of air observed to be circulating, per minute, in each of the splits, during each experiment :—

	No. of the Experiment.	Longest or East Way, 3,260 Yards long on the Average.	Medium or North Way, 2,142 Yards long on the Average.	Shortest or South Way, 1,490 Yards long on the Average	Gross Quantity of Air in all the Splits.	Per Centage of gross Quantity before Contraction.
		Cubic Feet.	Cubic Feet.	Cubic Feet.	Cubic Feet.	
	1	7,943	15,300	6,619	29,862	100
	2	7,363	13,255	5,926	26,544	89·42
	3	7,520	11,900	5,580	25,000	84·23
	4	5,680	10,151	3,763	19,594	62·64

The following table shows the proportion or per centage of the gross quantities of air circulating per minute, that passed through the routes of each of the splits :—

	No. of the Experiment.	Longest or East Way, 3,260 Yards long on the Average.	Medium or North Way, 2,142 Yards long on the Average.	Shortest or South Way, 1,490 Yards long on the Average.	Totals.	Sum of East and North Ways.	Sum of East and South Ways.	Sum of North and South Ways.
	1	26·60	51·24	22·16	100	77·84	48·76	73·40
	2	27·74	49·94	22·32	100	77·68	50·06	72·26
	3	30·08	47·60	22·32	100	77·68	52·40	69·92
	4	28·99	51·81	19·20	100	80·80	48·19	71·01
Average	..	28·35	50·15	21·50	100	78·50	49·85	71·65

If all the observations had been accurately made, and if no disturbing causes had existed, then, in order to prove that air splits or divides itself over any number of different splits, of different lengths, and offering different amounts of resistances to it, in the same mine, the whole of the per centages contained in each separate column of the preceding table, ought to have been equal to each other.

From the table, it will be seen, that the longest or east-way split, had, on the average of all the four experiments, 28·35 per cent. of the gross

quantity of air circulating through it; and, that the greatest departure from this, was when the greatest quantity of air was circulating, in No. I. experiment; when this, the longest split obtained $1\frac{3}{4}$ per cent. of the gross quantity of air, less than it obtained on the average of all the four experiments; this being directly contrary to the prevalent opinion, that the longest split gets the least share of the whole air, when it is smallest in amount; and, in like manner, this, the longest split, obtained nearly $\frac{3}{8}$ per cent. more of the gross quantity of air, in the fourth experiment (when the gross quantity of air circulating was smallest in amount) than it obtained in the average of all the experiments, contrary to the prevalent opinion, to the effect, that the longest split obtains a reduced share or proportion of the entire pit's air, as such entire pit's air becomes less and less in amount. Similar remarks apply to this split, in reference to the second and third experiments.

The greatest departure from the average proportion of the gross quantity in this split, however, as has been stated, occurs in No. I. experiment, and, being only to the extent of $1\frac{3}{4}$ per cent. of the gross amount of air in the three splits, it probably arises from irregularities in the air circulating, during the time of taking the measurements, in part; and in part to errors of observation.

The south way, or shortest route, in the first three experiments, obtains one and the same proportion, within $\frac{1}{6}$ per cent., of the gross quantity of air circulating in all the three splits, and does not, as popular opinion would indicate, obtain a sensibly increasing proportion of the gross quantity of air circulating in the mine, as such gross quantity becomes reduced in amount; on the contrary, indeed, the greatest departure from the average proportion, obtained by this, the shortest split, is in the fourth experiment, when the gross quantity of air circulating is least in amount; and then, instead of obtaining an increased, it actually appears to obtain a decreased proportion of the gross quantity circulating, to the extent of $2\frac{3}{10}$ per cent. of the average proportion of the gross quantity which it obtains in all the four experiments; and, this is the only instance, where, in this split, there is any material departure from a fixed proportion of the gross quantity; and it may, probably, arise only from irregularities in the quantity of air circulating, and errors of observation.

In the north way, offering the medium length of route or split, the per centages of the gross quantity of air circulating, when such gross quantity of air is greatest and least in amount, only differ from each other to the extent of little more than $\frac{1}{2}$ per cent. of the gross quantities; and, taking all the four experiments, that which has the greatest excess

above the average only differs from it to the extent of $1\frac{2}{3}$ per cent. of the gross quantities; while that which falls furthest below it, only does so the extent of about $2\frac{1}{2}$ per cent. of the gross quantities; and the latter discrepancy occurs when neither the greatest nor the least gross quantities are circulating.

Now, although the Grange Colliery, where these experiments were made, is one where the strata and air-ways are remarkably level, and the temperatures of the intakes and of the returns were, at the time of the experiments, almost identical, rendering it improbable that any serious interference could arise from changes in the density of the circulating air, in ascending and descending parts of the air-ways; and although the furnace was driven, as nearly as practicable, at a uniform rate, from a few hours before the commencement of the experiments, till after they were completed, yet the observations appear to indicate the discrepancies which have been alluded to.

After all, however, to those who are much accustomed to measure air in mines, the departures from a constant per centage (say the average per centage given in the last table), exhibited by the different splits, are no more than will appear likely to have arisen from changes in the gross quantities of air circulating, which have taken place between the times of making the measurements in the different splits, arising from firing the furnace, running cages in the shaft, opening and closing doors, &c.; indeed, the irregular manner in which the departures from the average per centage, in nearly all the splits, arise, sometimes increasing and again growing less; and at other times decreasing, and again growing larger, as the gross quantity of air circulating is successively reduced in amount over the four experiments, indicate, strongly, that these apparent discrepancies do really arise from the causes last named, together with the errors of observation necessarily attaching to so difficult an operation as that of measuring the quantities of air in the air-ways of a mine; and if this be admitted, we may, I think, fairly conclude that these experiments establish, so far as they go, the opinion that the air in mines does divide itself over any number of splits, in the same proportions, whatever may be the gross quantity of air circulating in the mine, except in so far as they are destroyed by changes of density in the air, in ascending and descending parts of the air-ways of the different splits.

Looking at the results of these experiments, in order to see how they bear upon the prevalent opinion, that where there are several splits in a mine, of different lengths, and offering different resistances to air, the shortest split will get a continually increasing, and the longest split a

continually decreasing, proportion of the gross quantity of air circulating through the whole of the splits, as such gross quantity becomes less and less in amount, while the state of all the air-ways remains unaltered; we observe that the very opposite of this, appears, from the table, to have been the case in these experiments, and that, although the departures from a fixed proportion are small in amount, and probably arise from the causes assigned, they really appear, on the face of them, rather to indicate that the short split obtained a reduced, and the longest one an increased, proportion of the gross quantity of air, as such gross quantity became less in amount, rather than the contrary; and, therefore, so far as they are reliable, these experiments appear to explode the popular opinion to the contrary.

Mr. Atkinson also submitted the following paper as an additional evidence of the square of the quantity of air being proportional to the resistance encountered by it.

In the Appendix to the paper, read by Mons. Laurent, to a meeting of the members of this Institute, on the 13th day of May, in the present year, "On the Lemielle System of Ventilating Mines," we have a further evidence of the prevalence of the law, of the square roots of the ventilating pressures being proportional to the quantities of air put into circulation in the unit of time, in the same mine, in the results of the experiments by Mons. Dormoy, French Government Mining Engineer, on the quantities of air circulated in the unit of time, by one of Mons. Lemielle's ventilating machines, at the St. Mary's Mine, concession of Azincourt, near Aniche, Department of Nord, on the 28th January, 1856.

The quantity of air was measured by one of Mons. Coombe's anemometers.

The ventilating machine at first revolved at the rate of 21 revolutions per minute; after that, the velocity was increased to 37 revolutions.

Eight successive experiments were made, of which the results were the following:—

Sets of Experiments.	Revolutions per Minute made by the Ventilating Machine.	Observed Ventilating Pressure in Height of Column of Water.	Quantity of Air circulated per Minute.
No.	No.	Inches.	Cubic Feet.
1	21	0·8	16,848
2	37	2·0	25,920

On the presumption, that the squares of the quantities of air circulated per minute are proportional to the pressures by which they are put into circulation, and, consequently, to the resistances encountered by them, in the same mine, we should have the proportion,

$$\text{As } \sqrt{\overset{\text{In.}}{0{\cdot}8}} : \sqrt{\overset{\text{In.}}{2{\cdot}0}} :: \overset{\text{Cub. Ft.}}{16{,}848} : \overset{\text{Cub. Ft.}}{26{,}639}$$

the observed quantity being 25,920 cubic feet, or, only 719 cubic feet per minute, (which is equal to about $2\frac{2}{3}$ per cent.) less than the calculated quantity; and this discrepancy is partly accounted for by the greater resistance due to the more expanded condition of the air, when the greater ventilating pressure is in operation, compared with its state of expansion, under the smaller ventilating pressure.

Mr. Knowles, of Temple Lodge, Pendlebury, near Manchester, then presented the model of a safety-cage apparatus, which he explained to the Institute, observing that there were twelve of them at work near Manchester. The cage, apparatus, and coals, weighed five tons twelve cwts; the cage and apparatus, two tons two cwts.

On the motion of the President, thanks were given to Mr. Knowles for the present of his model, and, on the motion of Mr. Dunn, thanks were given to Mr. Wales for his paper.